Report on:

Spatial Analysis of Bank and Check-Cashing Locations in Charlotte, NC

Prepared by:
Anthony Kolb
Doctoral Student
Environmental Science and Engineering Department
University of North Carolina-Chapel Hill

Submitted on:
December 30, 1999

To:
Prof. Michael Stegmen
Public Policy Analysis Curriculum
University of North Carolina-Chapel Hill

Abstract

This study investigates the relationship between bank and check-casher business locations and the socioeconomic characteristics of residents in the greater Charlotte metropolitan area. 226 banks and 91 check-cashers where identified in the Charlotte area as of August 1999. From this information, several spatial measures of bank and check-casher accessibility (measured as average distance to the nearest location) and availability (measured as the density or number of locations in a specific local area) where constructed using GIS functionality. Tabular summaries, correlation analysis and regression analysis were performed to explore the relationships between these accessibility and availability measures and corresponding 1990 Census data on socioeconomic conditions in those tracts.

Bank locations were found to be comparatively more accessible and available than check-casher locations in tracts with both low percentages of African American residents and high median household incomes. Although distances to the nearest bank and check-casher are largest in these tracts, banks are *comparatively* closer and more numerous. In tracts with higher proportions of African American residents and median incomes, both are closer and generally more numerous but check-cashers become *comparatively* closer and more numerous. On average, tracts inside and outside the inner city have similar levels of comparative bank and check-casher accessibility and availability. However, outside the city center there are about half as many banks and check-cashers per household as inside and distances to the nearest bank and check-casher location are almost twice as high.

The accessibility and availability measures were found to be highly spatially correlated, i.e., values in neighboring tracts tend to be similar—beyond what would be explained by the socioeconomic characteristics of the tracts themselves. By ignoring this spatial correlation, regression models over-predict the influence of tract socioeconomic characteristics on comparative accessibility and availability. Although both socioeconomic characteristics are highly correlated with the comparative availability and accessibility measures, in the regression analysis median income generally has weaker explanatory power in comparison to the percent of African American residents. However, it is difficult to conclude which of these two highly correlated variables truly is a better predictor of comparative check-casher and bank service especially as a high degree of heteroskedasticity exists in models of availability.

Table of Contents

I. Overview

This report aims to summarize the work performed by Anthony Kolb during August and September 1999 under contract with Prof. Michael Stegman. The focus of the work was to explore the relationship between the location of banks and check-cashing businesses in Charlotte, North Carolina and socioeconomic indicators available from the 1990 U.S. Census.

Prof. Stegman provided an original set of data and preliminary analysis compiled by another student research assistant, Jessica Leveen[1], in early 1999. The original data set was extensively modified to include missing information on the spatial location of banks and check-cashing businesses and to facilitate subsequent analysis.

This report contains details on:

- The sources of data and how they were compiled in this research;
- How the spatial location of Charlotte banks and check-cashing businesses were determined;
- A presentation of summary statistics (including updated tables originally prepared by Jessica Leveen) and spatial analysis on the banks and check-cashers.

[1] Contact information: JLeveen@aol.com,

II. Data Sources and Compilation

What follows is a description of the data sources for the analysis, how they were compiled, and the file names used to store the information in the project directories.

A. Banks

Two sources were used to come up with a database on current, bank branch office locations in Charlotte:

- The Powerfinder Pro 1998 Phone Listings;
- The U.S. FDIC Bank Office Database.

The Powerfinder Pro Phone Listings is on a commercial available CD-ROM format database. The database contains listings of a wide range of businesses throughout the United States. I queried the CD-ROM containing listings for the southeastern portion of the US on the bank SIC code, 602101, for Charlotte. The database identified 187 bank locations in Charlotte. The following table lists the information available from the database.

Table 1: Powerfinder Pro Bank Data

Field Name	*Description*
Name	Bank name
Address	Street address
City	City
State	State
ZIP_Code	Zip code, mostly +4 codes
Phone	Phone number
Long_PP	Longitude of address
Lat_PP	Latitude of address
Owner_Per	Percent owner occupied dwellings in zip code
SIC_Code	Standard Industrial Code
Med_Inc	Range of median household income in zip code
House_Type	Predominant housing type in zip code
House_Value	Range of typical housing value in zip code

This data for the 187 identified banks is listed in the following Excel 97 file along with a newly assigned, unique identifying number (PP_#):
\Charlotte\banks\banks_powerpro.xls

In addition, I queried the bank office database maintained by the U.S. FDIC on their web site, www.fdic.gov. This site offers links to a number of data sets on banking services in the United States including data on "Individual Banks". These searchable databases:

> "allow users to find institutions and their branches in order to determine their status as insured depository institutions, their financial condition and their condition relative to other institutions. The databases may also contain other financial and

non-financial information about individual financial institutions as well as certain aggregate financial statistics for comparative use."

The database, "FDIC Financial Institutions and Branch Office Data" at www2.fdic.gov/structur/search/, was queried for offices in Charlotte, North Carolina on August 12, 1999[2]. The database identified 179 bank locations in Charlotte. Table 2 lists the information available from this database.

Table 2: FDIC Bank Data

Field Name	*Description*
Cert	Unique FDIC institution identification no.
Institution Name	Entire legal name of bank
Office Name	Branch or office name
Address	Street address
City	City
State	State
Zip Code	Zip code, no +4 codes available
County	County
Est Date	Date office established
Active	Indicating if office is active, all "Y" for yes
Procdate	Date database record processed
Bank Holding Company	Legal holding company name
Office Number	Sequential number assigned to an institution office within an individual entity, generally 00000 is the main office

This data for the 179 identified banks is listed in the following Excel 97 file along with a newly assigned, unique identifying number (FDIC_Rec):
\Charlotte\banks\FDIC_download.xls

Subsequently, the data from both sources was closely scrutinized to identify redundant records and any bank office locations identified in only one of the two databases. This process was complicated by the fact that the institutional names used in the two databases is often different (e.g., while "NationsBank" is the "common name" listed in most phone directories like Powerfinder the official institutional name listed in the FDIC database is "Bank of American, National Association"). Even more problematic were differences in the format of the street addresses used and inconsistencies in the zip codes identified in both databases. Table 3 summarizes the number of bank branch office locations jointly and singularly identified by the two data sources and selected for use in this analysis.

[2] The database is continually updated, so the date of query is important. For example, when the database was rechecked on September 2, 1999, two additional banks had been added.

Table 3: Summary of Bank Office Records: Data Sources

Source	*Number*
Both databases	135
FDIC database, only	44
PowerFinder Pro database, only	47
Total	226[3]

In the Excel 97 file, Charlotte\banks\bank_link.xls, I include information on how I linked jointly listed records, eliminated several redundant records, eliminated what I considered "non-bank" listings from the PowerFinder Pro data, and assigned a new inclusive identifying number (REF) in compiling the final bank database.

A Microsoft Access (version 2.0) file was then constructed to allow querying of the two, downloaded database files through use of an additional table constructed from the above "linking" spreadsheet. This "linking" table includes the unique reference numbers assigned to the two database sources and the inclusive identifying number (REF). This Access file is named:
Charlotte\banks\banks.mdb

By querying this Access file, any number of output tables can be constructed including data available from both data sources. Using this functionality, I compiled an Excel 97 file for use as input to the ArcView GIS (geographic information system) software for subsequent spatial analysis. The fields included in this file are summarized in Table 4, below. This file name is:
Charlotte\banks\bank_GIS_input.xls

Table 4: GIS Input Bank Data

Field Name	*Description*
REF	Assigned, unique identifying number
NAME_NEW	Standard name that I decided to use
STREET_ADD	Street address, some corrected from original databases
ZIP	Five digit zip code, some corrected from original databases[4]
ZIP_4	Four digit zip code extension, where available
CODING	Method used to determine location *(see section below)*
LONG	Longitude, corrected if PowerFinder data inaccurate *(see below)*
LAT	Latitude, corrected
Source	Database source
Office Name	Branch office name, FDIC database
Est_year	Year established, FDIC database
Est_date	Month/day established, FDIC database
Med_Inc	Range of median household income in zip code, PowerFinder
House_Type	Predominant housing type in zip code, PowerFinder
House_Value	Range of typical housing value in zip code, PowerFinder
Tract	Census tract where located, added later *(see section below)*

[3] Same total number as identified by Jessica Leveen.
[4] Where there was some uncertainty regarding the given zip code, the U.S. Postal Service database was consulted on their web site: www.usps.gov/ncsc/lookups/lookup_zip+4.html

B. Check-Cashing Businesses

The database on check-cashing businesses compiled for this research was primarily taken from the North Carolina Commissioner of Banks (NCCB) web site: www.banking.state.nc.us/. As check-cashers are a regulated financial institution in North Carolina they must register with the Commission. I assume the listing of check-cashing businesses on www.banking.state.nc.us/cclist.htm was compiled from these registration applications. The list is updated quite regularly. I downloaded the list on August 13, 1999, and it had been updated only 4 days earlier.

Downloading the list was quite difficult. No specific query function was available to select only businesses located in Charlotte, nor could you download the data in a readily accessible format. I was forced to import the entire statewide list (1031 records) into a text file and manually reformat it to allow it to be read into a database format (file: Charlotte\CheckCashers\CC_Commission_download.xls). The data available was also limited to the simple address information listed in Table 5.

Table 5: NC Commissioner of Banks: Check-Casher Data

Field Name	*Description*
Name	Business name, along with DBA (Doing Business under Assumed name)
Address	Street address
City	City
State	State
Zip_Code	Zip code, no +4 codes available

To this data was added a unique identifying number (NCCB_id). The full database was then queried to identify only businesses located in Charlotte. The resulting list of 91 check-cashers is listed in the following Excel 97 file: \Charlotte\CheckCashers\CC_NCCB.xls

Either because the check-cashing business is actually growing rapidly or because application information is backlogged, the number of Charlotte check-cashers in this data source increased from 83 in February 1999 when Jessica download this information to 91 when I obtained the listing. That is a 9% increase over six months (over one new business added each month).

In addition, I queried the 1998 PowerFinder Pro CD-ROM containing listings for the southeastern portion of the US on the check-casher SIC code, 609903, for Charlotte. This data source identified only 21 check-casher locations in Charlotte. Since the Powerfinder data is now over a year old, this low number may be further indication that the check-cashing business is growing rapidly in Charlotte. The PowerFinder database lists the same information for these businesses as indicated for banks in Table 1. The Powerfinder data for the 21 identified check-cashers is listed in the following Excel 97 file along with a newly assigned, unique identifying number (PP_ID): \Charlotte\CheckCashers\cc_powerpro.xls

Subsequently, the data from both sources was again scrutinized to identify jointly identified records and locations identified in only one of the two databases. Table 6 lists the number of check-cashers ultimately included in the database for this work and the source of the data for the identified locations.

Table 6: Summary of Check-casher Records: Data Sources

Source	*Number*
Both databases	19
NCCB database, only	72
Total	91

The process I followed in linking jointly identified records in the two database, eliminating two Powerfinder Pro records (thought not to be approved cash-checkers), and assigning a new unique identifying number (CC_ID) is summarized in the Excel 97 file:
Charlotte\CheckCashers\cc_link.xls

A Microsoft Access (version 2.0) file was also constructed to allow querying of the two, downloaded check-casher data sources through use of an additional table constructed from the above "linking" spreadsheet, just as for the bank database. This Access file is named:
Charlotte\CheckCashers\CheckC.mdb

Again, an Excel 97 file was constructed from a query on the Access database file and used as input to the ArcView GIS (geographic information system) software for subsequent spatial analysis. The fields included in this file are summarized in Table 7, below. This Excel file name is:
Charlotte\CheckCashers\cc_GIS_input.xls

Table 7: GIS Input Check-Casher Data

Field Name	*Description*
CC_ID	Assigned, unique identifying number
NAME_NEW	Standard name that I decided to use
STREET_ADD	Street address
ZIP	Five digit zip code, some corrected from original sources
ZIP_4	Four digit zip code extension, where available
CODING	Method used to determine location *(see section below)*
LONG	Longitude, corrected if PowerFinder data inaccurate *(see below)*
LAT	Latitude, corrected
Source	Database source
Tract	Census tract where located, added later *(see section below)*

C. Census Tracts

The socioeconomic data used in subsequent analysis was obtained from the 1990 U.S. Census. Jessica had downloaded most of this information from Davis Library CD-ROM's, but I added a few fields by looking up data on the web. I know of two web sites that can be used to query the 1990 Census data:

- venus.census.gov/cdrom/lookup
- factfinder.census.gov/java_prod/dads.ui.homePage.HomePage

I recommend the first site for its speed and ease of use. Table 8, in Annex 1, lists all the fields of data obtained from the census.

To this data was added a unique identifying number (Tract_id). This data for the 111 census tracts in Mecklenburg Count is listed in the following Excel 97 file: \Charlotte\Tracts\tracts_all.xls

Please note I do not include four county census tracts (Tract ID 62.01, 62.02, 63, and 64) in further analysis. These tracts lie north of Charlotte along Interstate Highway 77 and include the outlying communities of Huntersville and Davidson. However, tracts that cover the outlying but contiguous, urbanized communities of Mint Hill and Matthews to the southeast and Pineville to the southwest *are* included in this analysis. Subsequently, a total of 107 tracts will be displayed on maps and used in subsequent analysis.

III. Spatial Locations of Banks and Check-Cashing Business

Of course before any spatial analysis of banks and check-cashing businesses can be performed, the location of these facilities in Charlotte must be determined based on the address information obtained for each listing. There were two primary methods used to determine these locations:

- Geocoding using a 1990 census street database in ArcView.
- Looking up the address on the online address database service www.MapsOnUs.com.

Geocoding is the mechanism that allows one to use addresses to identify locations on a map. In the "help" menu of the GIS software used in this analysis, ArcView 3.0a, the geocoding process is partially described as follows:

> An address specifies a location in the same way that a geographic coordinate does. But since an address is merely a text string containing the information of house number, street name, direction, and/or zip codes, an address needs a mechanism to calculate the geographic coordinate for the address and then display the location on a map based on the assigned coordinate. To do so, addresses stored in tabular data files must first be associated with a geographic feature, usually in a street network. The coordinates of a data source can be used to calculate and assign coordinates to addresses if the data source features also have addresses.

Jessica performed the geocoding process in ArcView using a street database for Charlotte available from the 1990 Census. She provided the results of this process in several ArcView data files that identified bank and check-casher database information along with the spatial location. However, the success of the geocoding process depends on:

- the detail, currency, and overall quality of the street database, and;
- good matches between the format of the addresses in the bank and check-casher databases and the street database.

Because of shortcomings related to these criteria, the automated geocoding process only successfully identified locations for about 70% of the bank listings and 75% of the check-cashers. For the banks and check-cashers not identified by the geocoding process, I needed to "manually" look up their addresses using an alternative database. I used the online database service available on www.MapsOnUs.com. Using this service, I was able to determine interactively the latitude and longitude of the missing addresses. I added this new information to the data files that Jessica had prepared.

Finally, I used the latitude and longitude information on bank and check-casher listings in the PowerFinder Pro database to check against the locations found through geocoding and my manual searches. This crosschecking identified a number of errors in the geocoding process. Several of these errors were very severe (i.e., giving locations on opposite sides of the city) some were less so. Most of the geocoding errors were due to ambiguous street names (e.g., geocoding located several banks on Westinghouse St. to be on West St.). I checked all of the significantly large deviations (over 200 meters) between the PowerFinder Pro database and the other methods, again by manually checking the online address locator. I ultimately chose to use the location that appeared to be best confirmed by the online service *and* either the PowerFinder Pro database or the geocoding process. After completing this process, I feel confident that the locations used in subsequent analysis are of good quality. The ultimate sources used to determine bank and check-casher locations are summarized in Table 9 and 10. "Modified" in these tables refers to locations changed from geocoding results or initial manual determination after crosschecking.

Table 9: Methods Used to Determine Bank Map Location

Coding Method	*# of Banks*	*Percent*
Geocoding	133	59%
Manual	65	29%
Modified	28	12%
Total	226	100%

Table 10: Methods Used to Determine Check-Cashers Map Location

Coding Method	*# of Check-cashers*	*Percent*
Geocoding	66	73%
Manual	22	24%
Modified	3	3%
Total	91	100%

IV. Spatial Analysis

The first spatial analysis step was establishing some spatial measures of accessibility to and availability of banks and check-cashers for residents within each census tract so that the relationship between these measures and the socioeconomic characteristics of residents within these tracts could be explored. The tract by tract statistics calculated are listed in Table 11 and were added to the Excel file, tracts_all.xls.

Table 11: Additional Tract Measures/Information

Number	Field Name	Description
1	Ar_sqme	Area of tract, square meters
2	Ar_sqmil	Area of tract, square miles
3	Peri_me	Perimeter of tract, meters
4	X_UTM_ce	x coordinate of centroid, UTM Zone 17, meters
5	Y_UTM_ce	y coordinate of centroid, UTM Zone 17, meters
6	CWAC	City Within A City, 1 = in CWAC, 0 = not in CWAC
7	Charlott	1 = in Charlotte study area, 0 = 4 northern tracts
8	Dist_cen	Mean distance to the "city center", meters
Spatial Measures of Bank Locations (by tract)		
9	Bank_all	Number of banks in tract
10	Bdist_me	Mean distance to nearest bank, meters
11	Bdist_mi	Minimum distance to nearest bank, meters
12	Bdist_ma	Maximum distance to nearest bank, meters
13	Bank_Kpr	Banks in tract per 1000 persons in tract
14	Ba_10KHH	Banks in tract per 10,000 households in tract
Spatial Measures of Check-Casher Locations (by tract)		
15	Check_Ca	Number of check-cashers in tract
16	CCd_mean	Mean distance to nearest bank, meters
17	Ccd_min	Minimum distance to nearest bank, meters
18	Ccd_max	Maximum distance to nearest bank, meters
19	CC_Kper	Check-cashers in tract per 1000 persons in tract
20	CC_10KHH	Check-cashers in tract per 10,000 households in tract
Comparative Spatial Measures of Locations (by tract)		
21	B_CC_dis	Mean dist. to nearest bank/Mean dist. to nearest check-casher
22	DensCCB1	Mean # of checkcashers/Mean # of banks in 4,250 m radius
23	Dis_den1	B_CC_dis multiplied by DensCCB1

The first eight measures listed in Table 11 describe some spatial characteristics of the tracts themselves. The first two describe the areal size of each tract. Generally, tracts are smaller in the city center and increase in size toward the city periphery (minimum of 0.02 sq. miles, maximum of 26.8 sq. miles and average of 4.1 sq. miles). The next two measures are the x-y coordinates of the centroid of each tract in the UTM (Universal Transverse Mercator) coordinate system. The next measure indicates whether a tract is considered to be within the CWAC (city within a city)[5]. The seventh measure indicates whether or not each of the 111 Mecklenburg County tracts included in the database is considered to be part of the greater

[5] This designation was provided by Jessica and includes 48 of the 107 tracts considered to be in "Charlotte".

Charlotte metropolitan area[6]. The final general measure is the distance from the "city center" (defined as the centroid of Tract 1, which covers the central downtown business district) to the centroid of each tract. The distance to the furthest tract, Tract 103, is just over 13 miles.

The second two sets of spatial measures in Table 11 attempt to measure the accessibility and availability of bank and check-cashers to residents within each tract. First, I simply list the number of banks and check-cashers determined to be located in each tract. Tract location was determined using the ArcView command that allows one to select all points located within a particular tract (or "polygon" in ArcView parlance). After selecting each bank and check-casher location within a tract, the tract ID was added to the bank and check-casher databases. Summary counts per tract were then compiled from these updated databases.

The next three bank and check-casher measures describe the estimated distance to the nearest bank or check-casher location for tract residents. I consider this a measure of **accessibility**. These distance figures were calculated by first establishing a grid of 100-meter by 100-meter cells over the entire city area[7]. I then calculated the distance from the center of each of these cells to the nearest bank and check-casher location. Finally, I summarized statistics for these distances (the mean, minimum and maximum) by the tract in which each cell was predominantly contained[8].

The final two bank and check-casher measures summarize the ratio of banks and check-cashers to residents within each tract. The ratios are calculated by dividing the number of these locations per tract first by the number of persons and secondly by the number of households in each tract identified in the 1990 Census. Of the 107 tracts in Charlotte, 38 have no banks and 67 contain no check-cashers. In the 107 Charlotte tracts, the average number of banks per 1000 persons is 0.66 while the average number of check-cashers per 1000 persons is 0.20.

The final set of measures listed in Table 11 attempt to characterize the **comparative** accessibility or availability of bank versus check-cashers to residents within each tract. The first measure is simply the ratio of the mean distance to the nearest bank to the mean distance to the nearest check-casher. I propose this as a measure of comparative **accessibility**. A value greater than one indicates that on average the nearest check-casher is closer than the nearest bank, and less than one – a bank is closer. The average value of this ratio over the 107 Charlotte tracts is 0.90, the minimum is 0.17 and the maximum value 10.2. This maximum value, which was calculated for Tract 51.01, is considered an anomaly. This anomaly results from this particular tract being unusually small in size (triangular in shape only 300 m in length on each side and only containing 7 households and 20 persons according to the 1990 census) and having a check-casher located very nearby (only about 300 m from the centroid). The average of the distance ratio ignoring this anomalous value is 0.81.

[6] As noted previously only the four northernmost counties are considered **not** to be part of the greater Charlotte area.

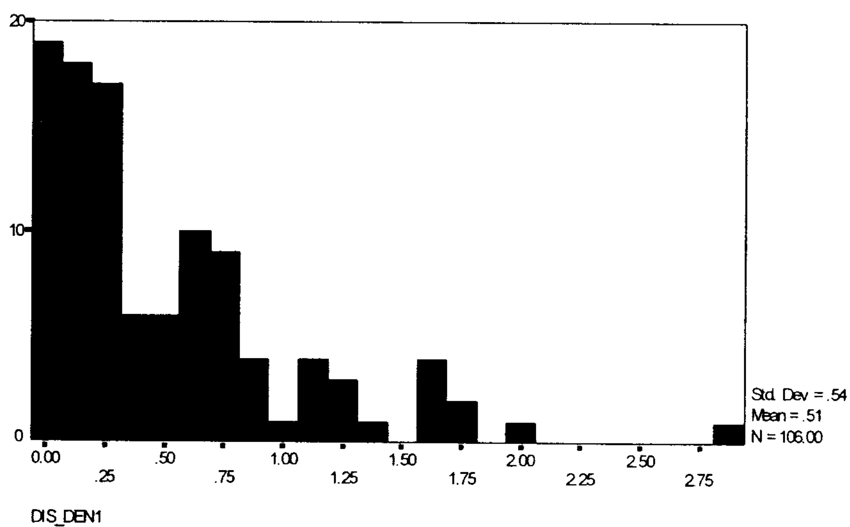
[7] Note: Calculation of this measure assumes that residents are located throughout the area cover by each tract.

[8] These tasks were completed using the Spatial Analyst Extension to ArcView 3.0. This add-on software for the ArcView GIS software allows analysis of what is called "raster" or grid formatted data.

The second comparative measure attempts to characterize the comparative spatial density of banks and check-cashers nearby tract residents. I propose this as a measure of comparative **availability**. This measure was calculated by initially separately calculating the spatial density of banks and check-cashers. These densities were again calculated by initially defining a grid of 100-meter by 100-meter cells over the entire city. From the centroid of each cell, the number of bank and check-cashers was counted in a 4,250-meter radius[9] and divided by the area of this circle. I then calculated the mean of these cell-by-cell densities by the tract in which each cell was predominantly contained[10]. Finally, I divided of the mean density of check-cashers by the corresponding mean bank density to come up with the comparative ratio value listed in Table 11. The maximum value of this ratio is 2.0, the minimum is 0.0 and the average over the 107 Charlotte tracts is 0.53. Although the maximum value of 2.0 was again calculated for Tract 51.01, I don't consider this value to be anomalous as several other tracts had values almost as high and this density measure. Only one tract, Tract 30.07, had a density ratio of zero, i.e., no check-cashers within 4,250 m of the tract boundary.

Both of the comparative distance and density ratios indicate comparatively *higher* levels of check-casher service to bank service as the values *increase*. The final measure listed in Table 11 attempts to characterize the **combination** of both accessibility and availability by simply taking the product of the first two measures. The distribution of values for the resulting measure is illustrated by the histogram in Figure 1 (Note: the anomalous value for Tract 51.01 of 20.5 is omitted in this figure). The average of this measure is 0.70 or 0.51 not considering the Tract 51.01 value.

Figure 1: Histogram of Comparative Nearest Distance × Density Measure



[9] The value of 4,250 meters was chosen for two reasons:
1) It is roughly the maximum minimum-distance between NationsBank branches in Charlotte. NationsBank, with 43 of the 226 bank locations, is the largest service provider in the city.
2) It resulted in non-zero, mean bank density calculations for each tract.
[10] These tasks were completed using the Spatial Analyst Extension to ArcView 3.0. This add-on software for the ArcView GIS software allows analysis of what is called "raster" formatted data.

In the remainder of this section, I summarize various statistics related to these measures of accessibility and availability and relate them to available socioeconomic characteristics. First, I provide some tabular summaries of the measures following Jessica's original format. Secondly, I provide information on correlation coefficients between the comparative measures and various socioeconomic data. In the final sub-section, I present the results of some regression analysis on the comparative measures and socioeconomic data. However, before I proceed, I need to clarify two points.

First, please note that there are several tracts for which some measures can not be calculated:
- Tract 2: The 1990 Census records no residents in this downtown tract. Therefore, for this tract it is not possible to calculate the (banks *or* cash-checkers)/(person *or* household) ratios nor the percent of population that is African American, below the poverty limit, etc.
- Tract 28: The Census records no African American population in this tract. Therefore, the natural logarithm of percent African American can not be calculated.
- Tract 51.01: This tract also has no African American population. In addition, it is also the tract identified to have an anomalous nearest bank/cash-checker ratio.

As a result, these tracts are simply dropped from calculations including these problematic figures.

Secondly, for some of the spatial analysis it was necessary to construct spatial weight matrices, W, relating the location of each tract to its neighbors. I constructed three weight matrices based on simple contiguity. In a simple contiguity weight matrix, element w_{ij} of the matrix equal one if tract i and tract j are "neighbors" and zero otherwise. The three, 107 by 107 weight matrices constructed vary by how the tracts were classified as neighbors, as follows:
- BORDER: neighbors if tracts share a border;
- DIST1: neighbors if tract centroids are within 4,250 m of one another; and,
- DIST2: neighbors if tract centroids are within 8,500 m of one another.

A. *Jessica's Tables*

Annex 2 includes Tables 12-17—updates of the tables originally prepared by Jessica. The tables are arranged in three sets of two each. The three sets compare information on the location of banks and check-cashers versus:

1. Percent African American population in each tract;
2. Median household income in each tract; and,
3. Whether a tract is located inside or outside the city within a city (CWAC).

The first table in each set compares the above tract characteristics with the number of banks and checker-cashers per 10,000 households in each tract and the ratio of banks to check-cashers found in each tract. The second table in each set compares the above tract characteristics with my new comparative service measures:

1. The average distance to the nearest bank;
2. The average distance to the nearest check-casher;

3. The ratio of the average distance of the nearest bank to the average distance to nearest check-casher;
4. The ratio of the average number of check-cashers within a 4,250 m radius to the average number of check-cashers within a 4,250 m radius (the "density" measure); and,
5. The product of the comparative distance and density ratios.

These tables suggest the following conclusions:

- Table 12 and 13 indicate that banks better serve tracts with a low proportion of African American residents (less than 10 percent of the total) than do check-cashers. Although the distances to the nearest bank and check-cashers are the largest in these tracts, banks are comparatively closer and more numerous in these tracts. In tracts with higher proportions of African American residents, both banks and check-cashers are closer and generally more numerous but check-cashers become *comparatively* closer and more numerous.

- Table 14 and 15 indicate that, generally, banks better serve tracts with higher median incomes than do check-cashers. This observation would be expected to follow from the observation from Table 12 and 13 as tracts with higher median incomes generally have lower proportions of African American residents.

- Tables 16 and 17 indicate that on average tracts inside and outside the city within a city (CWAC) have quite similar comparative levels of bank and check-casher service. However, outside the CWAC there are about half as many banks and check-cashers per household as inside the CWAC and the distances to the nearest bank and check-casher location are almost twice as high.

B. Correlation Coefficients

To further explore the relationships suggested by the summary tables, I chose to calculate a number of correlation coefficients between the comparative accessibility and availability measures and tract socioeconomic and location information. I have divided the calculated correlation coefficients into four sets comparing various measures as follows:

1. Comparative Measures vs. Distance to Center and Population Density
2. Comparative Measures vs. Household Income Indicators
3. Comparative Measures vs. Percent African American and Vacancy Rate
4. Summary of All Non-Comparative Measures

For each of the first three sets of measures I calculated three types of correlation coefficients, as follows:

1. Pearson Correlation Coefficient
2. Spearman Correlation Coefficient
3. Wartenberg Multivariate Spatial Correlation Coefficient

The **Pearson** correlation is a measure of linear relationship between two variables calculated by dividing the covariance between the variables by the product of the variance of the two variables. It varies between +1 and –1. The absolute value of the coefficient indicates the strength of the relationship, with larger absolute values indicating stronger relationship, i.e., correlation coefficients are near zero when values are unrelated. The sign of the coefficient indicates the direction of the relationship, i.e., when large values of one set are associated with large values of the other (positive correlation), whether small values of one set are associated with large values of the other (negative correlation).

The **Spearman** correlation coefficient is a nonparametric version of the Pearson correlation coefficient based on the rank of the values rather than the values themselves. It is appropriate for data that does not satisfy the normality condition and exhibit non-linear relationships. Like the Pearson coefficient, it also varies between +1 and –1. The absolute value of the coefficient also indicates the strength of the relationship and the sign of the coefficient indicates the direction of the relationship.

The multivariate measure of spatial correlation computed as part of this work follows the approach suggested by **Wartenberg** (1985) and implemented in the SpaceStat software package [Anselin, 1995]. This is the first statistic presented in this report that incorporates information on not only the value of variables in a particular tract but also the value of variables in neighboring tracts. The Wartenberg coefficient matrix is constructed similarly to the Pearson coefficient matrix but additionally uses the spatial weights matrix[11] to incorporate information on the correlation between values in neighboring tracts. Annex 3 explains the calculation of this coefficient in more detail.

Aslelin (1985) suggests that the interpretation of this multivariate measure of spatial association should be considered for exploratory purposes only, since a traditional significant test on all coefficients would create severe problems of multiple comparisons. However, this alternative correlation coefficient was checked to examine the consistency of sign (negative versus positive correlation) and relative magnitude with the non-spatial Pearson and Spearman correlation coefficients.

It is important to note, however, that by incorporating information on the typically imperfectly correlated neighboring values of a variable, the diagonal elements of the Wartenberg coefficient matrix will generally not equal one. Rather, these diagonal elements are similar to the traditional *spatial autocorrelation* statistic, Moran's *I*. Tests on spatial autocorrelation explore the existence of spatial dependence or a functional relationship between what happens at one point in space and what happens elsewhere. Positive spatial autocorrelation indicates that a variable has similar values appearing close together, while negative spatial autocorrelation indicates dissimilar values appearing in close association. In large samples[12], a Moran's *I* statistics larger than zero indicate increasing positive spatial correlation, and a Moran's I less than zero indicate negative spatial autocorrelation.

[11] Note: All three spatial weights matrices defined earlier were used in calculating this coefficient.
[12] In our case, I consider 107 tracts to be a large sample.

Annex 4 contains the four sets of correlation coefficients comparing the different variables detailed above. All three types of correlation coefficients were calculated for the first three sets, while only the Pearson and Spearman coefficients were calculated for the final set. Three separate tables of the Wartenberg coefficient are listed for the first three sets. These tables correspond to varying calculations using the three different spatial weights matrices. Therefore, there is a total of 17 tables (Table 18 – 34) in the annex. I summarize some observations from a review of these tables as follows:

Set 1: Comparative Measures vs. Distance to Center and Population Density

- The comparative measures are all similarly but only weakly correlated with population density and the distance of a tract to the center of the city.

- The comparative measures' consistently negative correlation with distance to city center and positive correlation with population density, indicate that check-casher services are generally *less* available/accessible further from the city center and *more* available in higher density tracts. This inverse relationship is confirmed by the negative correlation between population density and distanced to city center, i.e., tracts close to the city center tend to be densely populated.

- The choice of spatial weights matrix has little effect on these conclusions.

Set 2: Comparative Measures vs. Household Income Indicators

- The comparative measures are all fairly highly correlated with median household income and the other indicators of household economic wellbeing.

- The Spearman correlation coefficients between the comparative measures and the household income indicators are generally larger and more significant than the Pearson coefficients indicating a non-linear relationship between these variables.

- The comparative measures' consistently negative correlation with median household income and positive correlation with unemployment percentage, poverty percentage and public assistance percentage, indicate that check-casher services are generally comparatively *less* available/accessible in higher median income tracts and comparatively *more* available in tracts exhibiting signs of economic stress.

- The choice of spatial weights matrix has little effect on these conclusions.

Set 3: Comparative Measures vs. Percent African American and Vacancy Rate

- The comparative measures are all fairly highly correlated with the percent of African American residents and uncorrelated with dwelling vacancy rate.

- The Spearman correlation coefficients between the comparative measures and the percent African American residents are larger and more significant than the Pearson coefficients indicating a non-linear relationship between these variables.

- The comparative measures' consistently positive correlation with percent African American residents, indicate that check-casher services are comparatively *more* available/accessible in tracts with a higher percentage of African American residents.

- The choice of spatial weights matrix has little effect on these conclusions.

Set 4: Summary of All Non-Comparative Measures

- Household median income and the other income measures are highly, negatively correlated with percent African American residents, i.e.; tracts with high percentages of African American residents have lower incomes and higher rates of poverty, unemployment, and persons on public assistance.

Spatial Autocorrelation

- The diagonal elements of the Wartenberg correlation matrices suggest that each of the comparative measures is highly spatially correlated, i.e., neighboring tracts have similar values. The density of bank vs. check-cashers is particularly highly spatially correlated.

- The income indicators, especially median income, and the percentage of African American residents are also highly spatially correlated.

Given the strong and consistent relationship between the comparative measures and several tract socioeconomic conditions, I decided to extent the analysis to include multivariate linear regression to further explore these relationships. From the regression analysis, I hoped to more clearly quantify the comparative strength of these relationships.

C. Regression Analysis

The correlation coefficient analysis suggested three things to me, specifically that:

- each of the tract income measures and the percent of African American residents would be most likely to figure strongly in various model formulations;
- transformations of both the comparative measures and some of the explanatory socioeconomic variables would likely improve model fit and ensure satisfaction of normality conditions; and,
- ignoring the spatial autocorrelation apparent in the data may be a problem.

I formulated numerous models of the three comparative measures using a variety of combinations of the socioeconomic explanatory variables with many different transformation schemes. The results generally confirmed my suspicions from the correlation coefficient analysis. The following explanatory variables consistently figured significantly in these models:

- Median household income (not transformed) – MED_INC
- $\log_e$ (Percent African American residents) – BL_PR_LN
- Percent of residents below the poverty level (not transformed) – POV_RPER
- $\log_e$ (Percent of residents utilizing public assistance) – LN_PUB

I found the following transformations of the comparative measures provided the most consistent and acceptable results, particularly regarding normality in the residuals of the models:

- $\log_e$ (Mean distance to nearest bank/Mean distance to check-casher) – LN_DIS
- square root (Mean number of check-cashers/Mean number of banks) – SQR_DENS
- square root (Product of Distance and Density measure) – SQR_CMB

I only present here the results obtained when using these transformed dependent variables and the reduced and transformed set of independent variables listed above. Additional formulations can easily be regenerated later if required.

The final challenge was to account for possible spatial autocorrelation in the regression models. In a regression framework, spatial autocorrelation is the situation where the dependent variable or/and the error term of a regression function, at each location, is correlated with observations on the dependent variable or/and values of the error term at other locations. If spatial autocorrelation exists in cross-sectional data like that being analyzed here, ignoring it in standard econometric analysis can result in model misspecification problems similar to the problems involved when time dependence is ignored in serial data, e.g., efficiency problems, biased and inconsistent estimators, and omitted variable problems.

The spatial econometric literature has developed over the past several decades to specifically address the problem of identifying and accounting for spatial effects in regional and urban economic models. In contrasting spatial econometrics with standard econometrics, Anselin [1988] defines the field as consisting of:

> *...those methods and techniques that, based on a formal representation of the spatial structure of dependence and spatial heterogeneity, provide the means to carry out the proper specification, estimation, hypothesis testing, and prediction for models in regional science.*

This "formal representation" of spatial dependence most commonly involves formulation of spatial linear regression models. Anselin [1988] provides a useful taxonomy of the models common to many spatial econometric studies based on the general model:

$$y = \rho W_1 y + X\beta + \varepsilon$$
$$\varepsilon = \lambda W_2 \varepsilon + \mu$$

Here, y is the N by 1 matrix of the dependent variables, in our case the transformed comparative measures. ∃ is a K by 1 vector of parameters associated with exogenous variables X (N by K matrix), Δ is the coefficient of a spatially lagged dependent variable, and 8 is the coefficient in a spatially autoregressive structure for the error ,. The error, :, is taken to be normally distributed. The two N by N matrices, W_1 and W_2, are spatial weight matrices respectively associated with a spatial autoregressive process in the dependent variable and in the error term.

Several common spatial model structures result when various parameters of the general model are set to zero, as follows:

For: Δ = 0, 8 = 0

$$y = X\beta + \varepsilon$$

Results in the classical linear regression model with no spatial effects.

For: 8 = 0

$$y = \rho W_1 y + X\beta + \varepsilon$$

Results in the spatial autoregressive or spatial lag model. In our analysis, this type of model formulation would be formulated to test for the existence of interdependency in the comparative measures. Finding *Δ* to be significantly larger than zero would argue for the existence of a direct interdependent relationship in the comparative measure values between tracts.

For: Δ = 0

$$y = X\beta + (I - \lambda W_2)^{-1} \mu$$

Results in the linear regression model with a spatial autoregressive error. This model would be used to test for spatial correlation in comparative measures as a result of some common shock or unmeasured variable.

I tested each of these model formulations in the SpaceStat software package [Anselin, 1995]. Annex 5 lists the diagnostic output from SpaceStat for each of these model formulations for models on the comparative nearest distance, density and distance-density product measures—a total of nine models. In general, the models with no spatial effects were inferior in each case to both the spatial autoregressive error and spatial lag models for each comparative measure. Thus, I do not discuss them further here. Table 34 lists some descriptive statistics on the dependent variables. Table 35 summarizes information on the model coefficients for variables in the non-spatial and spatial lag models as well as several model fit parameters.

Table 34: Dependent Variables – Descriptive Statistics

Variable	*Mean*	*St.Dev.*	*Skewness*	*Kurtosis*
LN_DIS	-0.34	0.584	-0.462	2.59
SQR_DENS	0.68	0.294	0.057	2.89
SQR_CMB	0.64	0.363	0.402	2.71

Table 35: Comparative Measures Regression Models

	LN_DIS		***SQR_DENS***		***SQR_CMB***	
	Non-spatial	*Lag*	*Non-spatial*	*Lag*	*Non-spatial*	*Lag*
MED_INC* (1000 $)	-0.021 *0.0033*	-0.013 *0.040*	-0.013 *0.00003*	-0.007 *0.0010*	-0.013 *0.0038*	-0.006 *0.051*
BL_PR_LN	0.22 *0.0003*	0.15 *0.021*	0.16 *0.00000*	0.08 *0.0011*	0.21 *0.00000*	0.14 *0.0001*
POV_RPER (%)	-1.53 *0.016*	-1.08 *0.051*	-1.38 *0.000001*	-0.86 *0.000020*	-1.55 *0.00002*	-1.07 *0.00032*
LN_PUB	-0.152 *0.51*	-0.026 *0.76*	-0.060 *0.15*	-0.022 *0.48*	-0.052 *0.33*	-0.018 *0.70*
Δ		0.50 *0.000003*		0.65 *0.00000*		0.52 *0.00000*
CONSTANT	0.69 *0.048*	0.55 *0.075*	1.348 *0*	0.645 *0.000003*	1.41 *0*	0.83 *0.00002*
Log Likelihood	-63.4	-55.7	22.94	45.0	-4.7	7.0
AIC	136.8	123.0	-35.9	-77.9	19.5	-1.9
R^2	0.38		0.57		0.51	

* Values listed in the upper section are the model coefficients followed by the t-test probabilities in *italics*

Some observations on the regression analysis:

- The maximum log likelihood and Akaike Information Criteria (AIC) statistics consistently demonstrate considerable improved fit for the lag models over the non-spatial models for each dependent variable. However, even the non-spatial models have relatively good overall fit ($R^2 > 0.38$ and highly significant F-tests).

- A barely acceptable, high level of multicollinearity exists in the models (multicollinearity condition number of 19.9, below 20 is considered acceptable). This situation is expected based on the high correlation found between the explanatory variables included in the models.

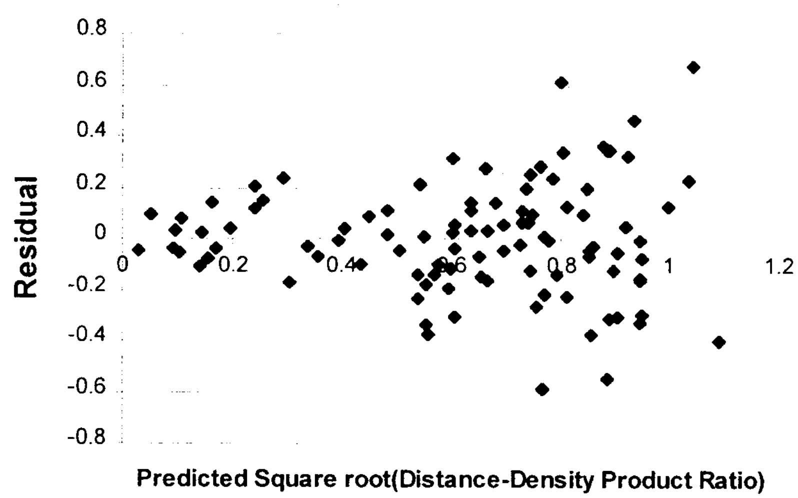
- The coefficients on the explanatory variables consistently are typically halved with inclusion of the lagged dependent variable, i.e. the non-spatial models over-predicts their influence on the comparative accessibility and availability measures. Instead, the highly significant lagged variable coefficient suggests that the conditions in neighboring tracts greatly influences the comparative service level in a particular tract and is less dependent on only the socioeconomic conditions in the tract itself.

- Although still highly significant in each model, median income generally has weaker explanatory power in comparison to the percent of African American residents. Separate reduced models omitting percent African American residents versus ones omitting median income also demonstrate the slightly lower explanatory power of median income. Regardless, it is difficult to conclude which of these highly correlated variables truly is a better predictor of comparative check-casher and bank service levels based on these tests.

- The signs on coefficient on poverty and public assistance are negative in each model and would be unexpected from the positive cross-correlation coefficients found between them and the comparative measures. This result indicates that in fact the poorest tracts are actually slightly more likely to have better bank service than check-casher service. I believe this is because of the higher concentration of banks in the downtown area where high poverty and public assistance use is concentrated along with the numerous Charlotte banking offices.

- The residuals from both the density and distance-density product models display a high degree of heteroskedasticity (highly significant Breusch-Pagan test statistics, $p<0.01$). Thus, the results from these models need to be examined with some caution. The consistent pattern of increasing residual values with increasing predicted values from these models is illustrated in Figure 2 using results from the spatial lag model on the distance-density measure. There are a number of possible explanations for this heteroskedasticity. I feel it is most likely due to changes in local socioeconomic conditions since the 1990 census from which the socioeconomic explanatory variables are drawn. Alternatively, I might be systematically excluding an important driving force behind the existence of concentrated numbers of check-casher locations, such as proximity to particular types of commercial zones. I explored this possibility by adding a variable to these models describing average tract distance to major thoroughfares. Unfortunately, the value I calculated did not improve the models.

Figure 2: Predicted Distance-Density Values vs. Model Residuals (Spatial Lag Model)



V. GIS Display – Maps

I include in Annex 6 maps produced displaying the socioeconomic indictors, bank and check-casher locations and comparative measures. A copy of each map in bitmap graphics file format (.bmp) has also been saved. Each map was produced using the GIS software package, ArcView 3.0a. Additional maps can readily be produced using the ArcView files[13] compiled as part of this work. The maps shown in Annex 6 and the associated bitmap file names are listed here:

1. **Location of Banks – August 1999**: Point location of identified banks along with Charlotte census tract boundaries, CWAC boundary, and Interstate and US highway locations. /Charlotte/Key/banks.bmp
2. **Location of Check-Cashing Businesses – August 1999**: Point location of identified check-cashers along with Charlotte census tract boundaries, CWAC boundary, and Interstate and US highway locations. /Charlotte/Key/check_cashers.bmp
3. **Median Income of Households (by Census Tract)**: Tracts color-coded according to median household income (income groups: <$20,000, $20,001-$40,000, $40,001-$60,000, and >$60,000) along with CWAC boundary, and Interstate and US highway locations. /Charlotte/Key/income1.bmp
4. **Median Income of Households**: Same as previous but with income groupings based on quartiles of the values and with addition of bank and check-casher locations. /Charlotte/Key/income2.bmp
5. **Percent African American Residents**: Tracts color-coded according to percent of African American residents (percentage groups: <10%, 10-70%, and >70%) along with CWAC boundary, and Interstate and US highway locations. /Charlotte/Key/African_amer1.bmp
6. **Percent African American Residents**: Same as previous but with tracts color-coded according to percent of African American residents based on quartiles of these values and with addition of bank and check-casher locations. /Charlotte/Key/African_amer2.bmp
7. **Nearest Distance Ratio**: Ratio of average distance to nearest bank to average distance to nearest check-casher—the comparative accessibility measure. Values color-coded according to the quartiles of these values. CWAC boundary and major roads also indicated. /Charlotte/Key/distance1.bmp
8. **Density Ratio**: Ratio of number of check-cashers to number of banks within 4,250 m—comparative availability measure. Values color-coded according to the quartiles of these values. CWAC boundary and major roads also indicated. /Charlotte/Key/density1.bmp
9. **Product of Nearest Distance-Density Ratios**: Product of distance and density ratios—combined, comparative accessibility and availability measure. Values color-coded according to the quartiles of these values. CWAC boundary and major roads also indicated. /Charlotte/Key/distance_density1.bmp
10. **Residuals of Spatial Lag Model**: The residuals from the spatial lag, "best-fit" model of the square root of the product of distance and density ratios—combined, comparative accessibility and availability measure. The values are color-coded to highlight the

[13] Most of these ArcView files are located in /Charlotte/gis-working/. However, the primary ArcView file is /Charlotte/Key/Char_final.apr.

“extreme” values, < |0.2|, associated with the larger predicted values (see Figure 2) and which result in the observed heteroskedasticity. CWAC boundary and major roads are also indicated. /Charlotte/Key/dist_dens_residual.bmp

VI. References

Anselin, Luc (1988) *Spatial Econometrics: Methods and Models*, Netherlands: Kluwer Academic Publishers.

Anselin, Luc (1995) *SpaceStat, A Software Program for the Analysis of Spatial Data, Version 1.80*, Regional Research Institute, West Virginia University, Morgantown, WV.

Wartenberg, D. (1985). Multivariate spatial correlation: a method for exploratory geographical analysis. *Geographic Analysis* 17, 263-83.

Annex 1: Census Data Variable Descriptions

Table 8: Tract 1990 Census Data Downloaded

Field Name	*Description*
Key	Combination of state, county and tract census ID
State90	State census ID, 37 = North Carolina
County90	County census ID, 119 = Mecklenburg
Tract90	Census tract ID
Persons	Persons, total
Per_sqmi	Density, persons/sq. mile
Househld	Households, total
HH_sqmi	Density, households/sq. mile
Tot_male	Males, total
Tot_fema	Females, total
White	Race: White, total
Black	Race: Black, total
Black_pr	Race: % black, of total
Bl_pr_ln	Race: ln(%black)
Amer_ind	Race: American Indian, Eskimo, or Aleut, total
Asian_pa	Race: Asian or Pacific Islander, total
Other	Race: other, total
Hisp_wht	Hispanic origin by race: White
Hisp_blk	Hispanic origin by race: Black
Hisp__am	Hispanic origin by race: American Indian, etc.
Hisp__as	Hispanic origin by race: Asian, etc.
Hisp_oth	Hispanic origin by race: other
Tot_latn	Hispanic origin, total
Under_1	Age: persons under 1 year old
1_and_2	Age: persons 1 and 2 years old
etc.	*etc. until...*
85_above	Age: 85 years and over
Tot_ge18	Age: persons greater or equal to 18 years
Tot_ge16	Age: persons greater or equal to 16 years
Tot_ge_3	Age: persons greater or equal to 3 years
Enrl_pub	Enrolled in public elementary or high school, person 3 years or older
Enrl_prv	Enrolled in private elementary or high school, person 3 years or older
Less_9th	Education attainment persons 25 years and older: less than 9th grade
9th_to12	9th to 12th grade attained
High_sch	High school graduate
Some_col	Some college, no degree
Associat	Associate degree
Bachelor	Bachelor's degree
Graduate	Graduate or professional school
Less_$5K	Household Income in 1989: less than $5,000, number of households
$5K_to	$5,000 to $9,999
$10K_to	$10,000 to $12,499
etc.	*etc. until...*
$150K_o	$150,000 or more

Table 8 *(continued)*

Field Name	*Description*
Med_inc	Median household income, 1989, dollars
Per_cap	Per capita household income, 1989, dollars
Pub_asst	Households with public assistance income in 1989
Pub_no	Households without public assistance income
Pub_per	Percent of households with public assistance income in 1989
Emp_raw	Employed: persons 16 years and above in labor force, raw data
Unem_raw	Unemployed: persons 16 years and above in labor force
Unem_rpr	Percent of persons unemployed, raw data
Pov_rabv	Persons in households with income above poverty limit, 1989, raw data
Pov_rbel	Persons in households with income below poverty limit, 1989
Pov_rper	Percent of person in HH with income below poverty limit, raw data
Occupied	Occupied housing units
Vacant	Vacant housing units
Tot_Dwel	Total housing units
Vacant_p	Percent vacant housing units
Pov_ibel	Persons in households with income above poverty limit, 1989, imputed
Pov_iabv	Persons in households with income below poverty limit, 1989
Pov_iper	Percent of person in HH with income below poverty limit, imputed
Unem_imp	Employed: persons 16 years and above in labor force, imputed
Emp_imp	Unemployed: persons 16 years and above in labor force
Unem_ipr	Percent of persons unemployed, imputed

Annex 2: Jessica's Tables Updated

Spatial Measures vs. Percent African American Population in Tract

Table 12: Locations per Household vs. Percent African American Population

Percent African American	*Percent of Total Banks*	*Percent of Total Check Cashers*	*Percent of Total Population*	*Average No. Banks per 10,000 Households*	*Average No. Check Cashers per 10,000 Households*	*Ratio of Banks to Check Cashers*
<10%	42%	13%	38%	12.5	1.6	7.9
10%-70%	53%	65%	48%	20.3	6.4	2.0
>70%	4%	22%	14%	3.8	6.7	0.5
Total City	100%	100%	100%	14.5	4.8	2.5

Sources: US 1990 Census; Powerfinder Pro 1998 Phone Listings; US FDIC;
North Carolina Office of the Commissioner of Banks

Table 13: Comparative Measures vs. Percent African American Population

Percent African American	*Ave. Distance to Nearest Bank (m)*	*Ave. Distance to Nearest Check Casher (m)*	*Ratio Distance: Nearest Bank/Check Casher*	*Ratio Density: No. Check Cashers/ No. Banks (1)*	*Product: Ratio Distance x Ratio Density*
<10%	1,469	3,484	0.50	0.20	0.13
10%-70%	1,326	1,733	0.92	0.73	0.72
>70%	1,119	1,122	1.10	0.61	0.69
Total City	1,336	2,217	0.81	0.52	0.51

Sources: US 1990 Census; Powerfinder Pro 1998 Phone Listings; US FDIC;
North Carolina Office of the Commissioner of Banks
(1) Within 4,250 m radius

Spatial Measures vs. Median Household Income in Tract

Table 14: Locations per Household vs. Median Household Income

Median Household Income	*Percent of Total Banks*	*Percent of Total Check Cashers*	*Percent of Total Population*	*Average No. Banks per 10,000 Households*	*Average No. Check Cashers per 10,000 Households*	*Ratio of Banks to Check Cashers*
<$20,000	15%	9%	10%	33.6	5.4	4.4
$20,001-$40,000	41%	85%	55%	7.9	6.6	1.2
$40,001-$60,000	37%	7%	29%	13.9	1.3	13.8
>$60,000	7%	0%	5%	17.7	0.0	na
Total City	100%	100%	100%	14.5	4.8	2.5
Less Than 80% City Median Income (1)	29%	43%	24%	21	7.3	1.7

Sources: US 1990 Census; Powerfinder Pro 1998 Phone Listings; US FDIC;
North Carolina Office of the Commissioner of Banks

Table 15: Comparative Measures vs. Median Household Income

Median Household Income	*Ave. Distance to Nearest Bank (m)*	*Ave. Distance to Nearest Check Casher (m)*	*Ratio Distance: Nearest Bank/Check Casher*	*Ratio Density: No. Check Cashers/ No. Banks (1)*	*Product: Ratio Distance x Ratio Density*
<$20,000	903	1,130	0.88	0.51	0.44
$20,001-$40,000	1,331	1,697	0.97	0.70	0.74
$40,001-$60,000	1,631	3,651	0.51	0.24	0.18
>$60,000	1,435	4,370	0.33	0.06	0.02
Total City	1,327	2,202	0.81	0.52	0.51
Less Than 80% City Median Income (2)	927	1,051	0.98	0.62	0.60

Sources: US 1990 Census; Powerfinder Pro 1998 Phone Listings; US FDIC;
North Carolina Office of the Commissioner of Banks
(1) Within 4,250 m radius

Spatial Measures: Inside and Outside the City within a City (CWAC)

Table 16: Locations per Household vs. Location within CWAC

Area	*Percent of Total Banks*	*Percent of Total Check Cashers*	*Percent of Total Population*	*Ave. No. Banks per 10,000 Households*	*Ave. No. Check Cashers per 10,000 Households*	*Ratio of Banks to Check Cashers*
CWAC	45%	48%	31%	20.7	6.2	2.3
Outside CWAC	55%	52%	69%	9.5	3.6	2.6
Total City	100%	100%	100%	14.5	4.8	2.5

Sources: US 1990 Census; Powerfinder Pro 1998 Phone Listings; US FDIC;
North Carolina Office of the Commissioner of Banks

Table 17: Comparative Measures vs. Location within CWAC

Area	*Ave. Distance to Nearest Bank (m)*	*Ave. Distance to Nearest Check Casher (m)*	*Ratio Distance: Nearest Bank/Check Casher*	*Ratio Density: No. Check Cashers/ No. Banks (1)*	*Product: Ratio Distance x Ratio Density*
CWAC	924	1,152	0.93	0.56	0.54
Outside CWAC	1,648	3,039	0.71	0.49	0.49
Total City	1,327	2,202	0.81	0.52	0.51

Sources: US 1990 Census; Powerfinder Pro 1998 Phone Listings; US FDIC;
North Carolina Office of the Commissioner of Banks
(1) Within 4,250 m radius

Annex 3: Spatial Correlation Coefficient

The multivariate measure of spatial correlation computed as part of this work follows the approach suggested by Wartenberg (1985) and implemented in the SpaceStat software package [Anselin, 1995]. First, all variables are standardized:

$$z_k = (x_k - :_k) / \Phi_k$$

where the subscript k refers to the vector of observations on the k-th variable, $:_k$, is the mean for variable k, and Φ_k is its standard deviation. Also, the spatial weights matrix is converted to a stochastic matrix, i.e., a matrix for which all elements sum to one. The resulting matric (W^S) is always symmetric, with as elements

$$w^S_{ij} = w_{ij} / 3_i\, 3_j\, w_{ij}$$

where w_{ij} are the elements in the unstandardized weight matrix.

A matrix of coefficients of spatial association is constructed as:

$$M = Z'\, W^S\, Z$$

where Z is a matrix with the values for the standardized variables as columns. The association represented in this matrix is similar in form to a bivariate Moran coefficient between the variables k and l: $m_{kl} = z_k' W^S z_l$

The diagonal elements differ from the traditional Moran's I spatial autocorrelation* coefficients by a scale factor:

$$m_{kk} = z_k' W^S z_k$$

***Moran's I**
Formally, Moran's I is:

$$I = N / S_0\; 3_i\, 3_j\, w_{ij}\, (x_i - :)\, (x_j - :) / 3_i\, (x_j - :)^2$$

where N is the number of observtions, w_{ij} is the element in the spatial weights matrix corresponding to the observation pair i, j x_i and x_j are observations for locations i and j (with mean :), and S_0 is a scaling constant, $S_0 = 3_i\, 3_j\, w_{ij}$.

Moran's I is similar but not equivalent to a correlation coefficient and is not centered around 0. In fact, the theoretical mean of Moran's I is (–1 / N – 1). In other words, the expected value is negative and is only a function of sample size, N. Note however, that this mean will tend to zero as the sample size increases. A Moran's I coefficient larger than its expected value indicates positive spatial correlation, and a Moran's I less than its expected value indicates negative spatial autocorrelation.

Annex 4: Correlation Coefficients[14]

Set 1: Comparative Measures vs. Distance to Center and Population Density

Table 18: Correlation Coefficients – Set 1

	B_CC_DIS	*DENSCCB1*	*DIS_DEN1*	*DIST_CEN*	*HH_SQMI*	*PER_SQMI*
B_CC_DIS	1.00	0.50	0.74	***-0.33***	***0.26***	***0.34***
	N(106)	N(106)	N(106)	N(106)	N(106)	N(106)
	P= .	P= .000	P= .000	P= .001	P= .008	P= .000
DENSCCB1		1.00	0.89	***-0.27***	***0.15***	***0.20***
		N(106)	N(106)	N(106)	N(106)	N(106)
		P= .	P= .000	P= .005	P= .118	P= .040
DIS_DEN1			1.00	***-0.23***	***0.15***	***0.22***
			N(106)	N(106)	N(106)	N(106)
			P= .	P= .019	P= .119	P= .022
DIST_CEN				1.00	-0.53	-0.52
				N(106)	N(106)	N(106)
				P= .	P= .000	P= .000
HH_SQMI					1.00	0.96
					N(106)	N(106)
					P= .	P= .000
PER_SQMI						1.00
						N(106)
						P= .

(Coefficient / (Cases) / 2-tailed Significance)
" . " is printed if a coefficient cannot be computed

Table 19: Spearman Correlation Coefficients – Set 1

	B_CC_DIS	*DENSCCB1*	*DIS_DEN1*	*DIST_CEN*	*HH_SQMI*
DENSCCB1	0.65				
	N(106)				
	Sig .000				
DIS_DEN1	0.87	0.93			
	N(106)	N(106)			
	Sig .000	Sig .000			
DIST_CEN	***-0.31***	***-0.29***	***-0.32***		
	N(106)	N(106)	N(106)		
	Sig .001	Sig .002	Sig .001		
HH_SQMI	***0.25***	***0.24***	***0.26***	-0.51	
	N(106)	N(106)	N(106)	N(106)	
	Sig .011	Sig .014	Sig .009	Sig .000	
PER_SQMI	***0.30***	***0.30***	***0.33***	-0.50	0.96
	N(106)	N(106)	N(106)	N(106)	N(106)
	Sig .002	Sig .002	Sig .001	Sig .000	Sig .000

(Coefficient / (Cases) / 2-tailed Significance)
" . " is printed if a coefficient cannot be computed

[14] Table 8 in Annex 1 and Table 11 in the text provide descriptions of the variable names listed in these tables.

Table 20: Multivariate Spatial Correlation Matrix – Set 1: Contiguity Weights

	B_CC_DIS	*DENSCCB1*	*DIS_DEN1*	*DIST_CEN*	*HH_SQMI*	*PER_SQMI*
B_CC_DIS	*0.36*	0.39	0.32	***-0.22***	***0.11***	***0.14***
DENSCCB1		*0.60*	0.52	***-0.15***	***0.08***	***0.12***
DIS_DEN1			*0.44*	***-0.10***	***0.05***	***0.08***
DIST_CEN				*0.76*	-0.34	-0.32
HH_SQMI					*0.35*	0.32
PER_SQMI						*0.31*

Table 21: Multivariate Spatial Correlation Matrix – Set 1: Distance Weight 1

	B_CC_DIS	*DENSCCB1*	*DIS_DEN1*	*DIST_CEN*	*HH_SQMI*	*PER_SQMI*
B_CC_DIS	*0.15*	0.27	0.19	***-0.24***	***0.12***	***0.11***
DENSCCB1		*0.46*	0.42	***-0.01***	***0.08***	***0.13***
DIS_DEN1			*0.34*	***0.01***	***0.05***	***0.08***
DIST_CEN				*0.84*	-0.36	-0.35
HH_SQMI					*0.22*	0.19
PER_SQMI						*0.17*

Table 22: Multivariate Spatial Correlation Matrix – Set 1: Distance Weight 2

	B_CC_DIS	*DENSCCB1*	*DIS_DEN1*	*DIST_CEN*	*HH_SQMI*	*PER_SQMI*
B_CC_DIS	*0.15*	0.19	0.16	***-0.19***	***0.09***	***0.10***
DENSCCB1		*0.22*	0.20	***-0.16***	***0.08***	***0.10***
DIS_DEN1			*0.18*	***-0.13***	***0.06***	***0.08***
DIST_CEN				*0.51*	-0.24	-0.24
HH_SQMI					*0.19*	0.17
PER_SQMI						*0.16*

Set 2: Comparative Measures vs. Household Income Indicators

Table 23: Correlation Coefficients – Set 2

	B_CC_DIS	*DENSCCB1*	*DIS_DEN1*	*MED_INC*	*UNEM_RPR*	*POV_RPER*	*PUB_PER*
B_CC_DIS	1.00	0.50	0.74	***-0.47***	***0.22***	***0.26***	***0.34***
	N(106)	N(106)	N(106)	N(106)	N(103)	N(103)	N(105)
	P= .	P= .000	P= .000	P= .000	P= .023	P= .008	P= .000
DENSCCB1		1.00	0.89	***-0.38***	***0.17***	***0.05***	***0.05***
		N(106)	N(106)	N(106)	N(103)	N(103)	N(105)
		P= .	P= .000	P= .000	P= .096	P= .650	P= .627
DIS_DEN1			1.00	***-0.32***	***0.13***	***0.05***	***0.08***
			N(106)	N(106)	N(103)	N(103)	N(105)
			P= .	P= .001	P= .181	P= .648	P= .423
MED_INC				1.00	-0.56	-0.75	-0.66
				N(106)	N(103)	N(103)	N(105)
				P= .	P= .000	P= .000	P= .000
UNEM_RPR					1.00	0.76	0.77
					N(103)	N(103)	N(103)
					P= .	P= .000	P= .000
POV_RPER						1.00	0.87
						N(103)	N(103)
						P= .	P= .000
PUB_PER							1.00
							N(105)
							P= .

(Coefficient / (Cases) / 2-tailed Significance)
" . " is printed if a coefficient cannot be computed

Table 24: Spearman Correlation Coefficients – Set 2

DENSCCB1	0.65					
	N(106)					
	Sig .000					
DIS_DEN1	0.87	0.93				
	N(106)	N(106)				
	Sig .000	Sig .000				
MED_INC	***-0.50***	***-0.50***	***-0.53***			
	N(106)	N(106)	N(106)			
	Sig .000	Sig .000	Sig .000			
UNEM_RPR	***0.25***	***0.38***	***0.36***	-0.62		
	N(103)	N(103)	N(103)	N(103)		
	Sig .013	Sig .000	Sig .000	Sig .000		
POV_RPER	***0.42***	***0.39***	***0.42***	-0.90	0.67	
	N(103)	N(103)	N(103)	N(103)	N(103)	
	Sig .000	Sig .000	Sig .000	Sig .000	Sig .000	
PUB_PER	***0.45***	***0.45***	***0.48***	-0.85	0.58	0.81
	N(105)	N(105)	N(105)	N(105)	N(103)	N(103)
	Sig .000	Sig .000	Sig .000	Sig .000	Sig .000	Sig .000
	B_CC_DIS	*DENSCCB1*	*DIS_DEN1*	*MED_INC*	*UNEM_RPR*	*POV_RPER*

(Coefficient / (Cases) / 2-tailed Significance)

Table 25: Multivariate Spatial Correlation Matrix – Set 2: Contiguity Weights

	B_CC_DIS	*DENSCCB1*	*DIS_DEN1*	*MED_INC*	*UNEM_RPR*	*POV_RPER*	*PUB_PER*
B_CC_DIS	*0.36*	0.36	0.31	***-0.37***	***0.21***	***0.19***	***0.19***
DENSCCB1		*0.61*	0.52	***-0.33***	***0.15***	***0.08***	***0.07***
DIS_DEN1			*0.44*	***-0.27***	***0.13***	***0.06***	***0.05***
MED_INC				*0.59*	-0.38	-0.44	-0.43
UNEM_RPR					*0.36*	0.36	0.41
POV_RPER						*0.43*	0.45
PUB_PER							*0.46*

Table 26: Multivariate Spatial Correlation Matrix – Set 2: Distance Weights 1

	B_CC_DIS	*DENSCCB1*	*DIS_DEN1*	*MED_INC*	*UNEM_RPR*	*POV_RPER*	*PUB_PER*
B_CC_DIS	*0.15*	0.28	0.19	***-0.31***	***0.18***	***0.20***	***0.17***
DENSCCB1		*0.47*	0.41	***-0.19***	***0.13***	***0.03***	***0.04***
DIS_DEN1			*0.34*	***-0.15***	***0.09***	***0.01***	***0.00***
MED_INC				*0.58*	-0.42	-0.55	-0.53
UNEM_RPR					*0.30*	0.42	0.40
POV_RPER						*0.59*	0.57
PUB_PER							*0.54*

Table 27: Multivariate Spatial Correlation Matrix – Set 2: Distance Weights 2

	B_CC_DIS	*DENSCCB1*	*DIS_DEN1*	*MED_INC*	*UNEM_RPR*	*POV_RPER*	*PUB_PER*
B_CC_DIS	*0.15*	0.19	0.16	***-0.21***	***0.13***	***0.15***	***0.14***
DENSCCB1		*0.23*	0.20	***-0.21***	***0.14***	***0.15***	***0.14***
DIS_DEN1			*0.18*	***-0.18***	***0.12***	***0.13***	***0.12***
MED_INC				*0.36*	-0.24	-0.29	-0.27
UNEM_RPR					*0.15*	0.19	0.18
POV_RPER						*0.25*	0.23
PUB_PER							*0.21*

Set 3: Comparative Measures vs. Percent African American and Vacancy Rate

Table 28: Correlation Coefficients – Set 3

	B_CC_DIS	*DENSCCB1*	*DIS_DEN1*	*BLACK_PR*	*VACANT_P*
B_CC_DIS	1.00	0.50	0.74	***0.41***	***-0.001***
	N(106)	N(106)	N(106)	N(105)	N(105)
	P= .	P= .000	P= .000	P= .000	P= .991
DENSCCB1		1.00	0.89	***0.31***	***-0.05***
		N(106)	N(106)	N(105)	N(105)
		P= .	P= .000	P= .001	P= .618
DIS_DEN1			1.00	***0.31***	***-0.06***
			N(106)	N(105)	N(105)
			P= .	P= .001	P= .564
BLACK_PR				1.00	0.09
				N(105)	N(105)
				P= .	P= .342
VACANT_P					1.00
					N(105)
					P= .

(Coefficient / (Cases) / 2-tailed Significance)
" . " is printed if a coefficient cannot be computed

Table 29: Spearman Correlation Coefficients – Set 3

	B_CC_DIS	*DENSCCB1*	*DIS_DEN1*	*BLACK_PR*
DENSCCB1	0.65			
	N(106)			
	Sig .000			
DIS_DEN1	0.86	0.93		
	N(106)	N(106)		
	Sig .000	Sig .000		
BLACK_PR	***0.54***	***0.62***	***0.63***	
	N(105)	N(105)	N(105)	
	Sig .000	Sig .000	Sig .000	
VACANT_P	***0.02***	***0.05***	***0.06***	0.18
	N(105)	N(105)	N(105)	N(105)
	Sig .869	Sig .618	Sig .516	Sig .071

(Coefficient / (Cases) / 2-tailed Significance)
" . " is printed if a coefficient cannot be computed

Table 30: Multivariate Spatial Correlation Matrix – Set 3: Contiguity Weights

	B_CC_DIS	*DENSCCB1*	*DIS_DEN1*	*BLACK_PR*	*BL_PR_LN*	*VACANT_P*
B_CC_DIS	*0.36*	0.36	0.31	***0.23***	***0.36***	***0.04***
DENSCCB1		*0.60*	0.51	***0.24***	***0.40***	***0.05***
DIS_DEN1			*0.43*	***0.18***	***0.34***	***0.06***
BLACK_PR				*0.62*	0.61	0.06
BL_PR_LN					*0.67*	0.08
VACANT_P						*0.00*

Table 31: Multivariate Spatial Correlation Matrix – Set 3: Distance Weights 1

	B_CC_DIS	*DENSCCB1*	*DIS_DEN1*	*BLACK_PR*	*BL_PR_LN*	*VACANT_P*
B_CC_DIS	*0.16*	0.28	0.19	***0.24***	***0.32***	***0.07***
DENSCCB1		*0.47*	0.42	***0.16***	***0.26***	***0.00***
DIS_DEN1			*0.34*	***0.11***	***0.21***	***0.01***
BLACK_PR				*0.66*	0.60	0.14
BL_PR_LN					*0.60*	0.12
VACANT_P						*-0.01*

Table 32: Multivariate Spatial Correlation Matrix – Set 3: Distance Weights 2

	B_CC_DIS	*DENSCCB1*	*DIS_DEN1*	*BLACK_PR*	*BL_PR_LN*	*VACANT_P*
B_CC_DIS	*0.16*	0.20	0.17	***0.19***	***0.23***	***0.04***
DENSCCB1		*0.24*	0.22	***0.19***	***0.25***	***0.05***
DIS_DEN1			*0.19*	***0.17***	***0.22***	***0.05***
BLACK_PR				*0.34*	0.35	0.04
BL_PR_LN					*0.37*	0.05
VACANT_P						*-0.02*

Set 4: Non-Comparative Measures Summary

Table 33: Correlation Coefficients – Set 4

	DIST_CEN	*HH_SQMI*	*PER_SQMI*	*MED_INC*	*UNEM_RPR*	*POV_RPER*	*PUB_PER*	*BLACK_PR*	*VACANT_P*
DIST_CEN	1.00	-0.53	-0.52	0.71	-0.45	-0.61	-0.56	-0.59	-0.01
	N(106)	N(106)	N(106)	N(106)	N(103)	N(103)	N(105)	N(105)	N(105)
	P= .	P= .000	P= .000	P= .000	P= .000	P= .000	P= .000	P= .000	P= .930
HH_SQMI		1.00	0.96	-0.31	0.19	0.25	0.14	0.16	-0.11
		N(106)	N(106)	N(106)	N(103)	N(103)	N(105)	N(105)	N(105)
		P= .	P= .000	P= .001	P= .055	P= .011	P= .145	P= .109	P= .269
PER_SQMI			1.00	-0.34	0.34	0.34	0.28	0.30	-0.13
			N(106)	N(106)	N(103)	N(103)	N(105)	N(105)	N(105)
			P= .	P= .000	P= .000	P= .000	P= .004	P= .002	P= .201
MED_INC				1.00	-0.56	-0.75	-0.66	-0.72	-0.19
				N(106)	N(103)	N(103)	N(105)	N(105)	N(105)
				P= .	P= .000	P= .000	P= .000	P= .000	P= .055
UNEM_RPR					1.00	0.76	0.77	0.70	0.11
					N(103)	N(103)	N(103)	N(103)	N(103)
					P= .	P= .000	P= .000	P= .000	P= .282
POV_RPER						1.00	0.87	0.77	0.20
						N(103)	N(103)	N(103)	N(103)
						P= .	P= .000	P= .000	P= .041
PUB_PER							1.00	0.78	0.14
							N(105)	N(105)	N(105)
							P= .	P= .000	P= .164
BLACK_PR								1.00	0.09
								N(105)	N(105)
								P= .	P= .342
VACANT_P									1.00
									N(105)
									P= .

(Coefficient / (Cases) / 2-tailed Significance)
" . " is printed if a coefficient cannot be computed

Table 34: Spearman Correlation Coefficients – Set 4

	DIST_CEN	HH_SQMI	PER_SQMI	MED_INC	UNEM_RPR	POV_RPER	PUB_PER	BLACK_PR
HH_SQMI	-0.51 N(106) Sig .000							
PER_SQMI	-0.50 N(106) Sig .000	0.96 N(106) Sig .000						
MED_INC	0.77 N(106) Sig .000	-0.33 N(106) Sig .001	-0.36 N(106) Sig .000					
UNEM_RPR	-0.44 N(103) Sig .000	0.12 N(103) Sig .229	0.25 N(103) Sig .011	-0.62 N(103) Sig .000				
POV_RPER	-0.71 N(103) Sig .000	0.30 N(103) Sig .002	0.34 N(103) Sig .001	-0.90 N(103) Sig .000	0.67 N(103) Sig .000			
PUB_PER	-0.69 N(105) Sig .000	0.19 N(105) Sig .057	0.25 N(105) Sig .010	-0.85 N(105) Sig .000	0.58 N(103) Sig .000	0.81 N(103) Sig .000		
BLACK_PR	-0.61 N(105) Sig .000	0.18 N(105) Sig .071	0.28 N(105) Sig .004	-0.85 N(105) Sig .000	0.70 N(103) Sig .000	0.81 N(103) Sig .000	0.83 N(105) Sig .000	
VACANT_P	-0.03 N(105) Sig .739	0.00 N(105) Sig .999	-0.03 N(105) Sig .766	-0.23 N(105) Sig .018	0.23 N(103) Sig .020	0.26 N(103) Sig .007	0.19 N(105) Sig .050	0.18 N(105) Sig .071

(Coefficient / (Cases) / 2-tailed Significance)
" . " is printed if a coefficient cannot be computed

Annex 5: Regression Output

Nearest Distance Ratio

ORDINARY LEAST SQUARES ESTIMATION

```
DATA SET TRAC_REG
DEPENDENT VARIABLE     LN_DIS         OBS 100       VARS    5         DF  95
R2            0.3836     R2-adj        0.3576
LIK          -63.4192    AIC           136.838     SC            149.864
RSS           20.8151    F-test        14.7776     Prob   2.01187e-09
SIG-SQ       0.219106   (0.468088) SIG-SQ(ML)      0.208151   (0.456235)

VARIABLE      COEFF          S.D.         t-value         Prob
CONSTANT       0.69728     0.348777      1.999215       0.048442
 MED_INC-2.06385E-05 6.85501E-06     -3.010726       0.003338
BL_PR_LN      0.220625    0.0712848      3.094976       0.002586
POV_RPER      -1.52571     0.622785     -2.449823       0.016124
  LN_PUB  -0.0640437     0.097116     -0.659456       0.511198

REGRESSION DIAGNOSTICS

MULTICOLLINEARITY CONDITION NUMBER     19.871788

TEST ON NORMALITY OF ERRORS
TEST                     DF       VALUE          PROB
Jarque-Bera               2     3.875643      0.144017

DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS
TEST                     DF       VALUE          PROB
Breusch-Pagan test        4     1.749531      0.781702

SPECIFICATION ROBUST TEST
TEST                     DF       VALUE          PROB
White                    14    10.497449      0.724985

DIAGNOSTICS FOR SPATIAL DEPENDENCE
FOR WEIGHTS MATRIX TRAC_REG (row-standardized weights)
TEST                               MI/DF          VALUE           PROB
Moran's I (error)                0.220031       4.332031        0.000015
Lagrange Multiplier (error)             1      13.477281        0.000241
Robust LM (error)                       1       0.062634        0.802380
Kelejian-Robinson (error)               5      19.672370        0.001440
Lagrange Multiplier (lag)               1      16.426869        0.000051
Robust LM (lag)                         1       3.012223        0.082639
Lagrange Multiplier (SARMA)             2      16.489504        0.000263
```

FOR WEIGHTS MATRIX **DIS1_REG** (row-standardized weights)
WARNING: weights matrix contains zero rows

TEST	MI/DF	VALUE	PROB
Moran's I (error)	0.051375	1.460726	0.144091
Lagrange Multiplier (error)	1	0.844501	0.358113
Robust LM (error)	1	1.262893	0.261104
Kelejian-Robinson (error)	5	13.094922	0.022505
Lagrange Multiplier (lag)	1	4.597770	0.032014
Robust LM (lag)	1	5.016162	0.025112
Lagrange Multiplier (SARMA)	2	5.860663	0.053379

FOR WEIGHTS MATRIX **DIS2_REG** (row-standardized weights)

TEST	MI/DF	VALUE	PROB
Moran's I (error)	0.016636	1.386087	0.165720
Lagrange Multiplier (error)	1	0.308626	0.578525
Robust LM (error)	1	0.005739	0.939614
Kelejian-Robinson (error)	5	4.713032	0.451896
Lagrange Multiplier (lag)	1	0.712278	0.398689
Robust LM (lag)	1	0.409391	0.522279
Lagrange Multiplier (SARMA)	2	0.718017	0.698368

SPATIAL ERROR MODEL - MAXIMUM LIKELIHOOD ESTIMATION

DATA SET TRAC_REG SPATIAL WEIGHTS MATRIX TRAC_REG

DEPENDENT VARIABLE		LN_DIS	OBS 100	VARS 5	DF 95	
R2	0.3249	Sq. Corr.	0.3662	R2(Buse)	0.2213	
LIK	-55.9929	AIC	121.986	SC	135.012	
SIG-SQ	0.167095	(0.408773)				

VARIABLE	COEFF	S.D.	z-value	Prob
CONSTANT	0.638818	0.331842	1.925067	0.054221
MED_INC	-1.347E-05	6.94416E-06	-1.939766	0.052408
BL_PR_LN	0.189777	0.0727891	2.607223	0.009128
POV_RPER	-1.06017	0.541564	-1.957600	0.050277
LN_PUB	0.0228457	0.0845795	0.270110	0.787076
LAMBDA	0.576562	0.10965	5.258216	0.000000

REGRESSION DIAGNOSTICS

DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS

TEST	DF	VALUE	PROB
Breusch-Pagan test	4	4.771911	0.311511
Spatial B-P test	4	4.771969	0.311505

DIAGNOSTICS FOR SPATIAL DEPENDENCE
SPATIAL ERROR DEPENDENCE FOR WEIGHTS MATRIX TRAC_REG (row-stand weights)

TEST	DF	VALUE	PROB
Likelihood Ratio Test	1	14.852759	0.000116

TEST ON COMMON FACTOR HYPOTHESIS

TEST	DF	VALUE	PROB
Likelihood Ratio Test	4	5.682138	0.224177
Wald Test	4	5.771860	0.216846

LAGRANGE MULTIPLIER TEST ON SPATIAL LAG DEPENDENCE

WEIGHT	STAND	ZERO	DF	VALUE	PROB
TRAC_REG	yes	no	1	2.636212	0.104452
DIS1_REG	yes	yes	1	0.152942	0.695740
DIS2_REG	yes	no	1	0.310658	0.577276

SPATIAL LAG MODEL - MAXIMUM LIKELIHOOD ESTIMATION

```
DATA SET TRAC_REG                           SPATIAL WEIGHTS MATRIX TRAC_REG
DEPENDENT VARIABLE     LN_DIS               OBS 100      VARS   6      DF  94
R2            0.4369    Sq. Corr.           0.3933
LIK          -55.7058   AIC                 123.412      SC          139.043
SIG-SQ        0.169484  (     0.411684 )
```

VARIABLE	COEFF	S.D.	z-value	Prob
W_LN_DIS	0.499853	0.106907	4.675582	0.000003
CONSTANT	0.551998	0.310492	1.777816	0.075434
MED_INC	-1.26306E-05	6.16321E-06	-2.049358	0.040427
BL_PR_LN	0.14961	0.0648216	2.308027	0.020998
POV_RPER	-1.08	0.554402	-1.948052	0.051409
LN_PUB	-0.0255633	0.0854167	-0.299277	0.764729

REGRESSION DIAGNOSTICS
DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS

TEST	DF	VALUE	PROB
Breusch-Pagan test	4	5.433962	0.245596
Spatial B-P test	4	5.434002	0.245592

DIAGNOSTICS FOR SPATIAL DEPENDENCE
SPATIAL LAG DEPENDENCE FOR WEIGHTS MATRIX TRAC_REG (row-stand weights)

TEST	DF	VALUE	PROB
Likelihood Ratio Test	1	15.426885	0.000086

LAGRANGE MULTIPLIER TEST ON SPATIAL ERROR DEPENDENCE

WEIGHT	STAND	ZERO	DF	VALUE	PROB
TRAC_REG	yes	no	1	1.629253	0.201806
DIS1_REG	yes	yes	1	1.317481	0.251045
DIS2_REG	yes	no	1	1.697899	0.192563

Density Ratio

ORDINARY LEAST SQUARES ESTIMATION

```
DATA SET TRAC_REG

DEPENDENT VARIABLE  SQR_DENS      OBS 100      VARS   5      DF  95
R2            0.5663     R2-adj      0.5481
LIK          22.9415     AIC       -35.8829    SC         -22.8571
RSS          3.70048     F-test     31.0148    Prob  1.62487e-16
SIG-SQ     0.0389525  (     0.197364 ) SIG-SQ(ML)    0.0370048   (    0.192366 )
```

VARIABLE	COEFF	S.D.	t-value	Prob
CONSTANT	1.34789	0.147058	9.165692	0.000000
MED_INC	-1.26193E-05	2.89033E-06	-4.366036	0.000032
BL_PR_LN	0.162199	0.0300564	5.396488	0.000000
POV_RPER	-1.37516	0.26259	-5.236918	0.000001
LN_PUB	-0.0601155	0.0409478	-1.468099	0.145381

REGRESSION DIAGNOSTICS

MULTICOLLINEARITY CONDITION NUMBER 19.871788

TEST ON NORMALITY OF ERRORS

TEST	DF	VALUE	PROB
Jarque-Bera	2	1.538534	0.463353

DIAGNOSTICS FOR HETEROSKEDASTICITY

RANDOM COEFFICIENTS

TEST	DF	VALUE	PROB
Breusch-Pagan test	4	9.301731	0.053985

SPECIFICATION ROBUST TEST

TEST	DF	VALUE	PROB
White	14	29.932010	0.007798

DIAGNOSTICS FOR SPATIAL DEPENDENCE

FOR WEIGHTS MATRIX TRAC_REG (row-standardized weights)

TEST	MI/DF	VALUE	PROB
Moran's I (error)	0.288057	5.542260	0.000000
Lagrange Multiplier (error)	1	23.098831	0.000002
Robust LM (error)	1	0.141455	0.706839
Kelejian-Robinson (error)	5	40.296330	0.000000
Lagrange Multiplier (lag)	1	44.989922	0.000000
Robust LM (lag)	1	22.032546	0.000003
Lagrange Multiplier (SARMA)	2	45.131377	0.000000

FOR WEIGHTS MATRIX DIS1_REG (row-standardized weights)

WARNING: weights matrix contains zero rows

TEST	MI/DF	VALUE	PROB
Moran's I (error)	0.344628	7.211879	0.000000
Lagrange Multiplier (error)	1	38.000517	0.000000
Robust LM (error)	1	13.984334	0.000184
Kelejian-Robinson (error)	5	107.526336	0.000000
Lagrange Multiplier (lag)	1	42.513687	0.000000
Robust LM (lag)	1	18.497504	0.000017
Lagrange Multiplier (SARMA)	2	56.498021	0.000000

FOR WEIGHTS MATRIX DIS2_REG (row-standardized weights)

TEST	MI/DF	VALUE	PROB
Moran's I (error)	0.106521	5.144724	0.000000
Lagrange Multiplier (error)	1	12.653207	0.000375
Robust LM (error)	1	1.178054	0.277753
Kelejian-Robinson (error)	5	49.887229	0.000000
Lagrange Multiplier (lag)	1	20.595430	0.000006
Robust LM (lag)	1	9.120276	0.002528
Lagrange Multiplier (SARMA)	2	21.773483	0.000019

VARIABLE	COEFF	S.D.	t-value	Prob
CONSTANT	1.34789	0.147058	9.165692	0.000000
MED_INC	-1.26193E-05	2.89033E-06	-4.366036	0.000032
BL_PR_LN	0.162199	0.0300564	5.396488	0.000000
POV_RPER	-1.37516	0.26259	-5.236918	0.000001
LN_PUB	-0.0601155	0.0409478	-1.468099	0.145381

REGRESSION DIAGNOSTICS

MULTICOLLINEARITY CONDITION NUMBER 19.871788

TEST ON NORMALITY OF ERRORS

TEST	DF	VALUE	PROB
Jarque-Bera	2	1.538534	0.463353

DIAGNOSTICS FOR HETEROSKEDASTICITY

RANDOM COEFFICIENTS

TEST	DF	VALUE	PROB
Breusch-Pagan test	4	9.301731	0.053985

SPECIFICATION ROBUST TEST

TEST	DF	VALUE	PROB
White	14	29.932010	0.007798

DIAGNOSTICS FOR SPATIAL DEPENDENCE

FOR WEIGHTS MATRIX TRAC_REG (row-standardized weights)

TEST	MI/DF	VALUE	PROB
Moran's I (error)	0.288057	5.542260	0.000000
Lagrange Multiplier (error)	1	23.098831	0.000002
Robust LM (error)	1	0.141455	0.706839
Kelejian-Robinson (error)	5	40.296330	0.000000
Lagrange Multiplier (lag)	1	44.989922	0.000000
Robust LM (lag)	1	22.032546	0.000003
Lagrange Multiplier (SARMA)	2	45.131377	0.000000

FOR WEIGHTS MATRIX DIS1_REG (row-standardized weights)

WARNING: weights matrix contains zero rows

TEST	MI/DF	VALUE	PROB
Moran's I (error)	0.344628	7.211879	0.000000
Lagrange Multiplier (error)	1	38.000517	0.000000
Robust LM (error)	1	13.984334	0.000184
Kelejian-Robinson (error)	5	107.526336	0.000000
Lagrange Multiplier (lag)	1	42.513687	0.000000
Robust LM (lag)	1	18.497504	0.000017
Lagrange Multiplier (SARMA)	2	56.498021	0.000000

FOR WEIGHTS MATRIX DIS2_REG (row-standardized weights)

TEST	MI/DF	VALUE	PROB
Moran's I (error)	0.106521	5.144724	0.000000
Lagrange Multiplier (error)	1	12.653207	0.000375
Robust LM (error)	1	1.178054	0.277753
Kelejian-Robinson (error)	5	49.887229	0.000000
Lagrange Multiplier (lag)	1	20.595430	0.000006
Robust LM (lag)	1	9.120276	0.002528
Lagrange Multiplier (SARMA)	2	21.773483	0.000019

SPATIAL ERROR MODEL - MAXIMUM LIKELIHOOD ESTIMATION

```
DATA SET TRAC_REG                         SPATIAL WEIGHTS MATRIX TRAC_REG
DEPENDENT VARIABLE  SQR_DENS              OBS 100        VARS   5        DF  95
R2            0.2286      Sq. Corr.      0.5286       R2(Buse)     0.2542
LIK          39.5861      AIC          -69.1722       SC          -56.1463
SIG-SQ     0.0228710    (     0.151232 )
```

VARIABLE	COEFF	S.D.	z-value	Prob
CONSTANT	1.14266	0.138336	8.260000	0.000000
MED_INC	-7.66158E-06	2.63735E-06	-2.905025	0.003672
BL_PR_LN	0.0814991	0.0278352	2.927917	0.003412
POV_RPER	-0.744865	0.198175	-3.758614	0.000171
LN_PUB	0.000960272	0.0309785	0.030998	0.975271
LAMBDA	0.772218	0.0750762	10.285792	0.000000

REGRESSION DIAGNOSTICS
DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS

TEST	DF	VALUE	PROB
Breusch-Pagan test	4	13.554911	0.008860
Spatial B-P test	4	13.557088	0.008851

DIAGNOSTICS FOR SPATIAL DEPENDENCE
SPATIAL ERROR DEPENDENCE FOR WEIGHTS MATRIX TRAC_REG (row-standardized weights)

TEST	DF	VALUE	PROB
Likelihood Ratio Test	1	33.289227	0.000000

TEST ON COMMON FACTOR HYPOTHESIS

TEST	DF	VALUE	PROB
Likelihood Ratio Test	4	17.509795	0.001538
Wald Test	4	17.068472	0.001875

LAGRANGE MULTIPLIER TEST ON SPATIAL LAG DEPENDENCE

WEIGHT	STAND	ZERO	DF	VALUE	PROB
TRAC_REG	yes	no	1	6.948275	0.008390
DIS1_REG	yes	yes	1	31.772250	0.000000
DIS2_REG	yes	no	1	1.469790	0.225379

SPATIAL LAG MODEL - MAXIMUM LIKELIHOOD ESTIMATION

```
DATA SET TRAC_REG                         SPATIAL WEIGHTS MATRIX TRAC_REG
DEPENDENT VARIABLE  SQR_DENS              OBS 100        VARS   6        DF  94
R2            0.6106      Sq. Corr.      0.6506
LIK          44.9526      AIC          -77.9053       SC          -62.2742
SIG-SQ     0.0216802    (     0.147242 )
```

VARIABLE	COEFF	S.D.	z-value	Prob
W_SQR_DE	0.648638	0.0763957	8.490506	0.000000
CONSTANT	0.644854	0.138273	4.663630	0.000003
MED_INC	-7.3391E-06	2.23168E-06	-3.288593	0.001007
BL_PR_LN	0.0779272	0.0238249	3.270830	0.001072
POV_RPER	-0.859851	0.201562	-4.265943	0.000020
LN_PUB	-0.0215878	0.0305997	-0.705491	0.480505

REGRESSION DIAGNOSTICS
DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS

TEST	DF	VALUE	PROB
Breusch-Pagan test	4	11.884067	0.018235
Spatial B-P test	4	11.884694	0.018230

```
DIAGNOSTICS FOR SPATIAL DEPENDENCE
SPATIAL LAG DEPENDENCE FOR WEIGHTS MATRIX TRAC_REG (row-standardized weights)
TEST                        DF       VALUE          PROB
Likelihood Ratio Test        1     44.022328      0.000000
LAGRANGE MULTIPLIER TEST ON SPATIAL ERROR DEPENDENCE
WEIGHT      STAND   ZERO    DF       VALUE          PROB
TRAC_REG     yes     no      1     0.105496       0.745331
DIS1_REG     yes    yes      1     5.813318       0.015905
DIS2_REG     yes     no      1     1.312369       0.251966
```

Product of Distance and Density Ratios

ORDINARY LEAST SQUARES ESTIMATION

```
DATA SET TRAC_REG
DEPENDENT VARIABLE    SQR_CMB         OBS 100        VARS    5        DF  95
R2            0.5076    R2-adj         0.4869
LIK         -4.74541    AIC            19.4908      SC            32.5167
RSS          6.43789    F-test         24.4857      Prob   6.07989e-14
SIG-SQ     0.0677673   (     0.260322 ) SIG-SQ(ML)      0.0643789   ( 0.253730 )

VARIABLE     COEFF          S.D.        t-value        Prob
CONSTANT       1.40284     0.193968      7.232349     0.000000
 MED_INC-1.13171E-05 3.81233E-06     -2.968558     0.003787
BL_PR_LN     0.213068     0.0396442      5.374505     0.000001
POV_RPER     -1.54645      0.346355     -4.464920     0.000022
  LN_PUB  -0.0519006     0.0540099     -0.960947     0.339018

REGRESSION DIAGNOSTICS

MULTICOLLINEARITY CONDITION NUMBER     19.871788

TEST ON NORMALITY OF ERRORS
TEST                     DF       VALUE          PROB
Jarque-Bera               2     0.320089       0.852106

DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS
TEST                     DF       VALUE          PROB
Breusch-Pagan test        4    15.814313       0.003279

SPECIFICATION ROBUST TEST
TEST                     DF       VALUE          PROB
White                    14    35.987059       0.001048

DIAGNOSTICS FOR SPATIAL DEPENDENCE
FOR WEIGHTS MATRIX TRAC_REG (row-standardized weights)
TEST                                   MI/DF        VALUE          PROB
Moran's I (error)                    0.238815      4.666197      0.000003
Lagrange Multiplier (error)                 1     15.876487      0.000068
Robust LM (error)                           1      0.017164      0.895766
Kelejian-Robinson (error)                   5     30.989777      0.000009
Lagrange Multiplier (lag)                   1     26.404713      0.000000
Robust LM (lag)                             1     10.545390      0.001165
Lagrange Multiplier (SARMA)                 2     26.421877      0.000002
```

SPATIAL ERROR MODEL - MAXIMUM LIKELIHOOD ESTIMATION

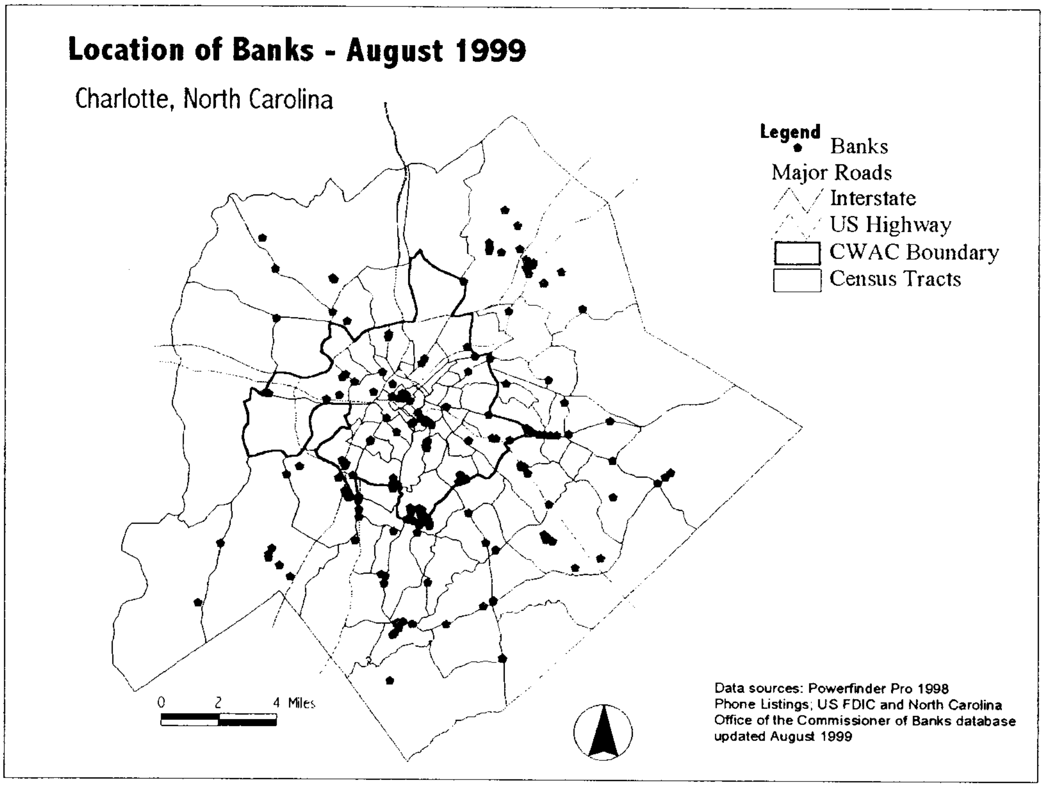
```
DATA SET TRAC_REG                        SPATIAL WEIGHTS MATRIX TRAC_REG
DEPENDENT VARIABLE    SQR_CMB            OBS 100       VARS   5        DF  95
R2            0.3367    Sq. Corr.    0.4743       R2(Buse)     0.2885
LIK           4.51711    AIC        0.965776      SC           13.9916
SIG-SQ      0.0491212   (     0.221633 )

VARIABLE      COEFF        S.D.         z-value        Prob
CONSTANT        1.2532     0.182945      6.850142      0.000000
 MED_INC-5.89916E-06 3.79349E-06     -1.555074      0.119928
BL_PR_LN      0.166636    0.0398147      4.185277      0.000028
POV_RPER      -0.94851      0.29307     -3.236466      0.001210
  LN_PUB  0.00688264    0.0457785      0.150347      0.880491
  LAMBDA      0.621972     0.102573      6.063717      0.000000

REGRESSION DIAGNOSTICS

DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS
TEST                     DF       VALUE          PROB
Breusch-Pagan test        4     19.811663      0.000544
Spatial B-P test          4     19.812121      0.000544

DIAGNOSTICS FOR SPATIAL DEPENDENCE

SPATIAL ERROR DEPENDENCE FOR WEIGHTS MATRIX TRAC_REG (row-stand weights)
TEST                           DF       VALUE          PROB
Likelihood Ratio Test           1     18.525044      0.000017
TEST ON COMMON FACTOR HYPOTHESIS
TEST                           DF       VALUE          PROB
Likelihood Ratio Test           4     14.566512      0.005690
Wald Test                       4     14.646903      0.005492
LAGRANGE MULTIPLIER TEST ON SPATIAL LAG DEPENDENCE
WEIGHT        STAND   ZERO     DF       VALUE          PROB
TRAC_REG       yes      no      1      2.477905      0.115456
```

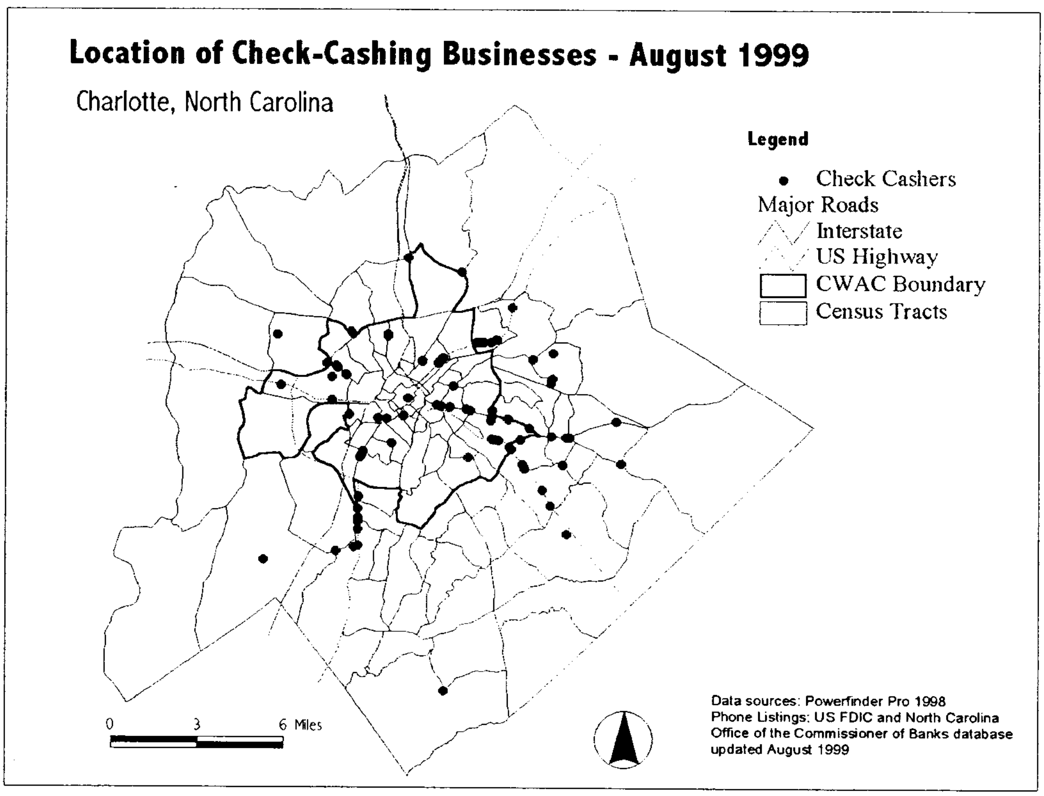
SPATIAL LAG MODEL - MAXIMUM LIKELIHOOD ESTIMATION

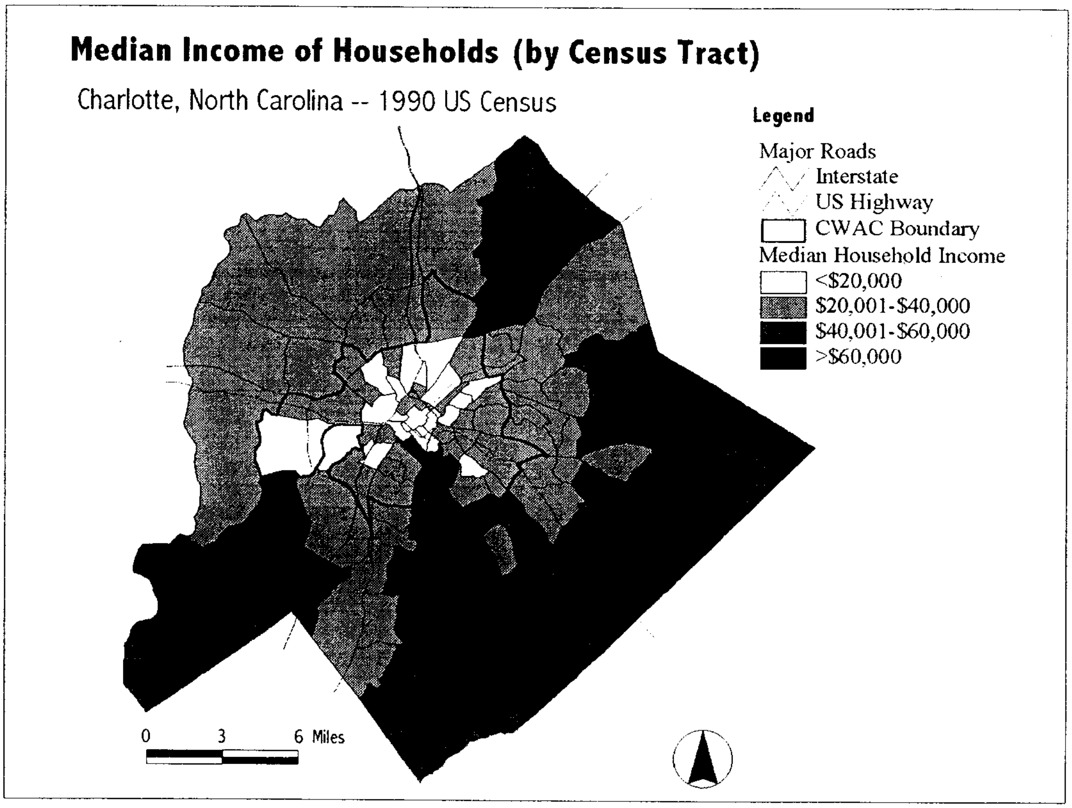
```
DATA SET TRAC_REG                        SPATIAL WEIGHTS MATRIX TRAC_REG
DEPENDENT VARIABLE    SQR_CMB            OBS 100       VARS   6        DF  94
R2            0.5387    Sq. Corr.    0.5488
LIK           6.95600    AIC        -1.91201      SC           13.7190
SIG-SQ      0.0481271   (     0.219379 )

VARIABLE      COEFF        S.D.         z-value        Prob
W_SQR_CM      0.523501     0.094864      5.518440      0.000000
CONSTANT      0.825989     0.194012      4.257423      0.000021
 MED_INC -6.3679E-06 3.26778E-06     -1.948691      0.051332
BL_PR_LN      0.138884    0.0358146      3.877861      0.000105
POV_RPER       -1.0736     0.298047     -3.602126      0.000316
  LN_PUB -0.0177591    0.0455469     -0.389908      0.696604
```

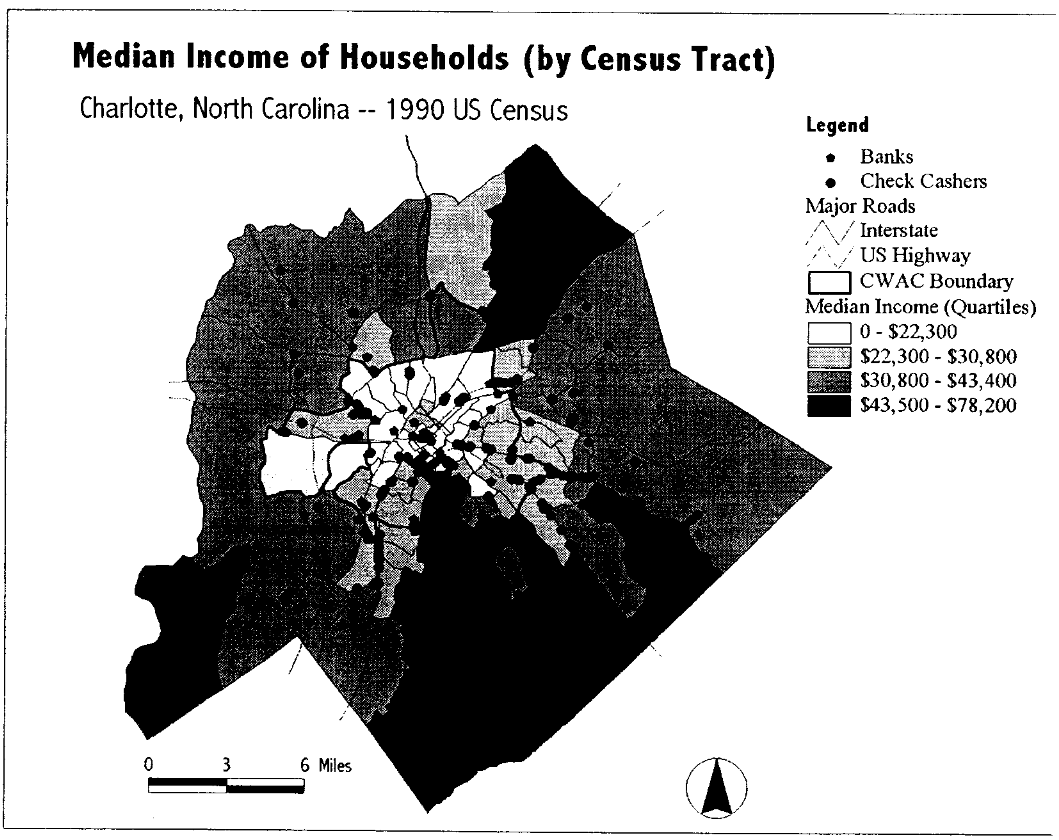
```
REGRESSION DIAGNOSTICS
DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS
TEST                  DF       VALUE         PROB
Breusch-Pagan test     4     20.369027     0.000422
Spatial B-P test       4     20.369154     0.000422
DIAGNOSTICS FOR SPATIAL DEPENDENCE
SPATIAL LAG DEPENDENCE FOR WEIGHTS MATRIX TRAC_REG (row-stand weights)
TEST                       DF       VALUE         PROB
Likelihood Ratio Test       1     23.402827     0.000001
LAGRANGE MULTIPLIER TEST ON SPATIAL ERROR DEPENDENCE
WEIGHT      STAND  ZERO    DF       VALUE         PROB
TRAC_REG     yes     no     1      0.001240      0.971907
```

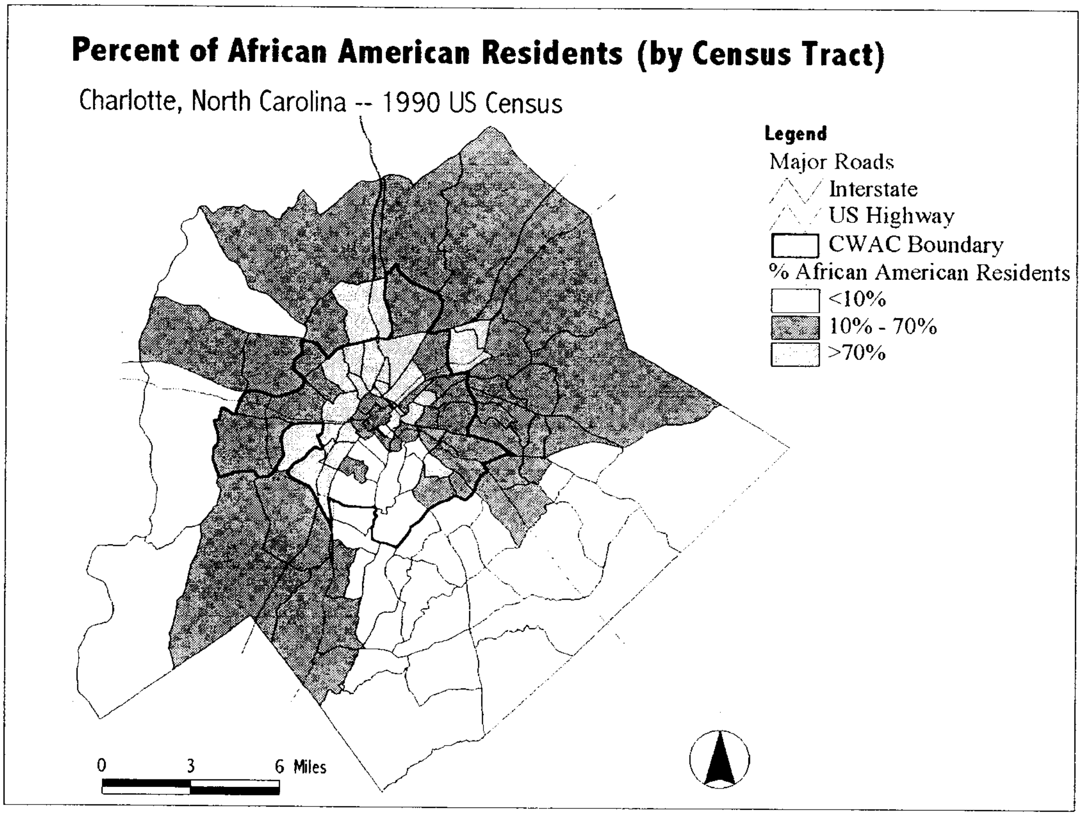
Annex 6: GIS Display – Maps

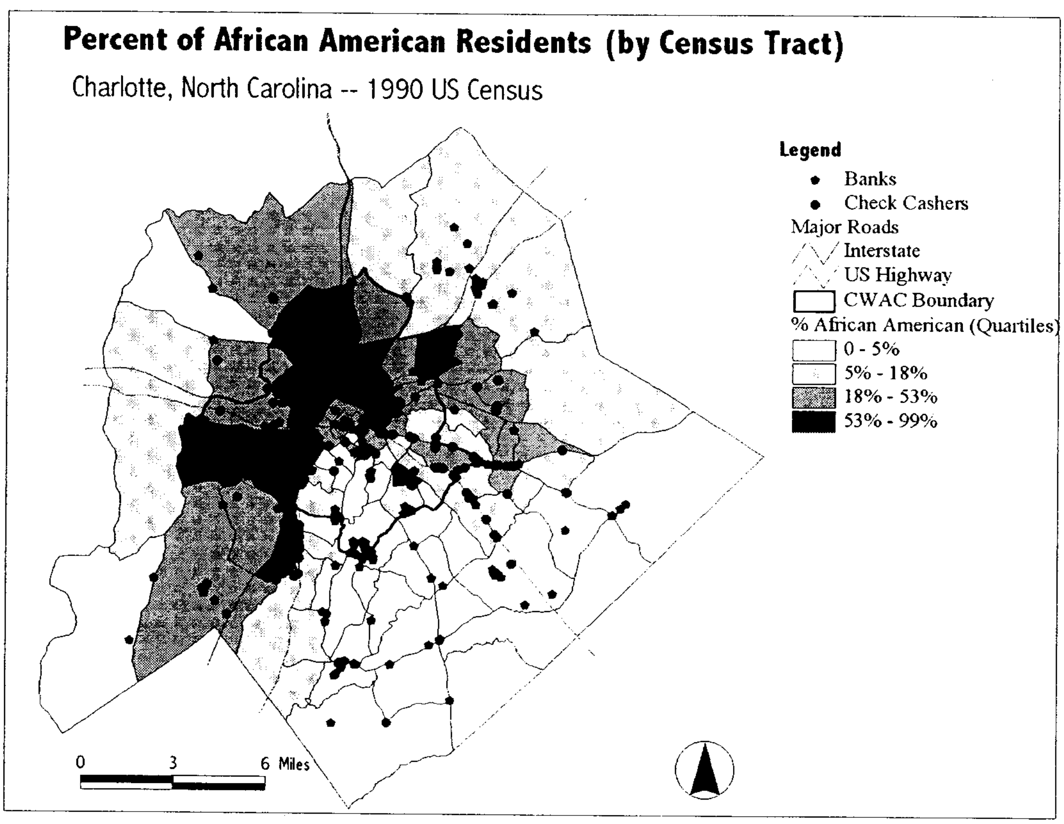




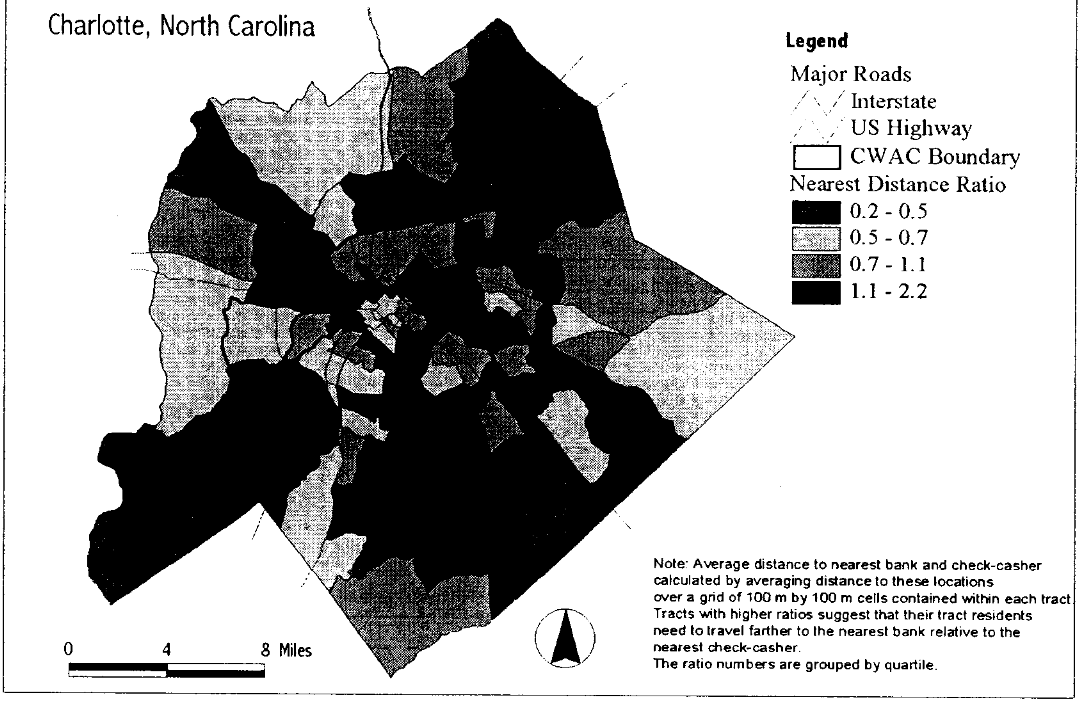

Median Income of Households (by Census Tract)
Charlotte, North Carolina -- 1990 US Census
Legend
Major Roads
Interstate
US Highway
CWAC Boundary
Median Household Income
<$20,000
$20,001-$40,000
$40,001-$60,000
>$60,000
0
3
6 Miles


Median Income of Households (by Census Tract)
Charlotte, North Carolina -- 1990 US Census
Legend
Banks
Check Cashers
Major Roads
Interstate
US Highway
CWAC Boundary
Median Income (Quartiles)
0 - $22,300
$22,300 - $30,800
$30,800 - $43,400
$43,500 - $78,200
0
3
6 Miles

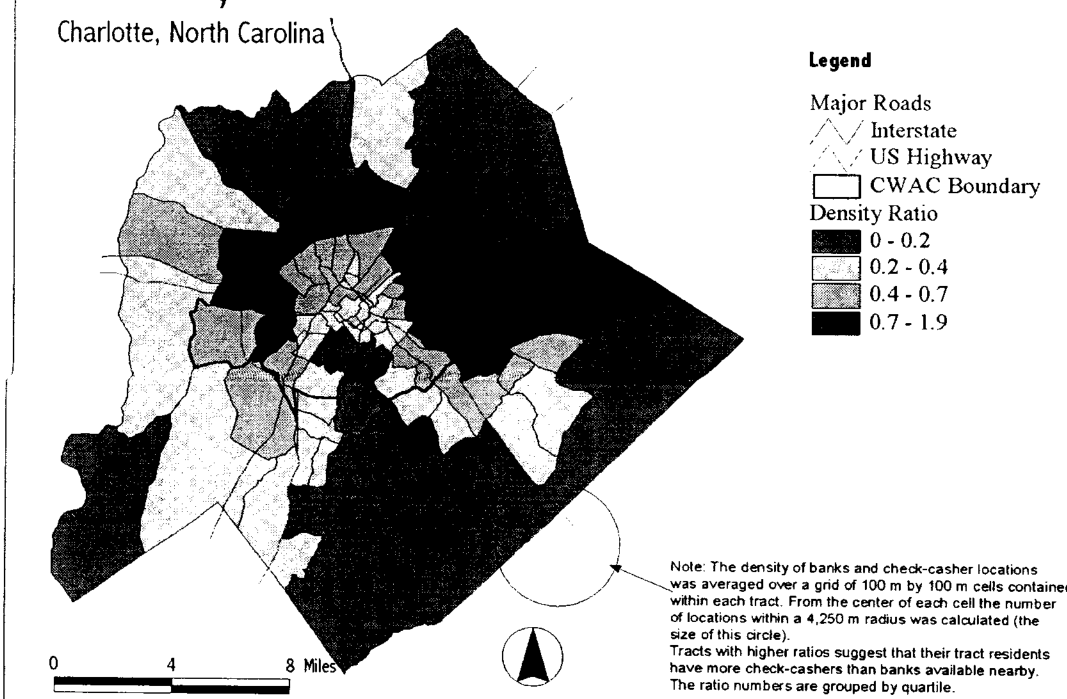

Percent of African American Residents (by Census Tract)
Charlotte, North Carolina -- 1990 US Census
Legend
Major Roads
Interstate
US Highway
CWAC Boundary
% African American Residents
<10%
10% - 70%
>70%
0
3
6 Miles


Percent of African American Residents (by Census Tract)
Charlotte, North Carolina -- 1990 US Census
Legend
Banks
Check Cashers
Major Roads
Interstate
US Highway
CWAC Boundary
% African American (Quartiles)
0 - 5%
5% - 18%
18% - 53%
53% - 99%
0
3
6 Miles

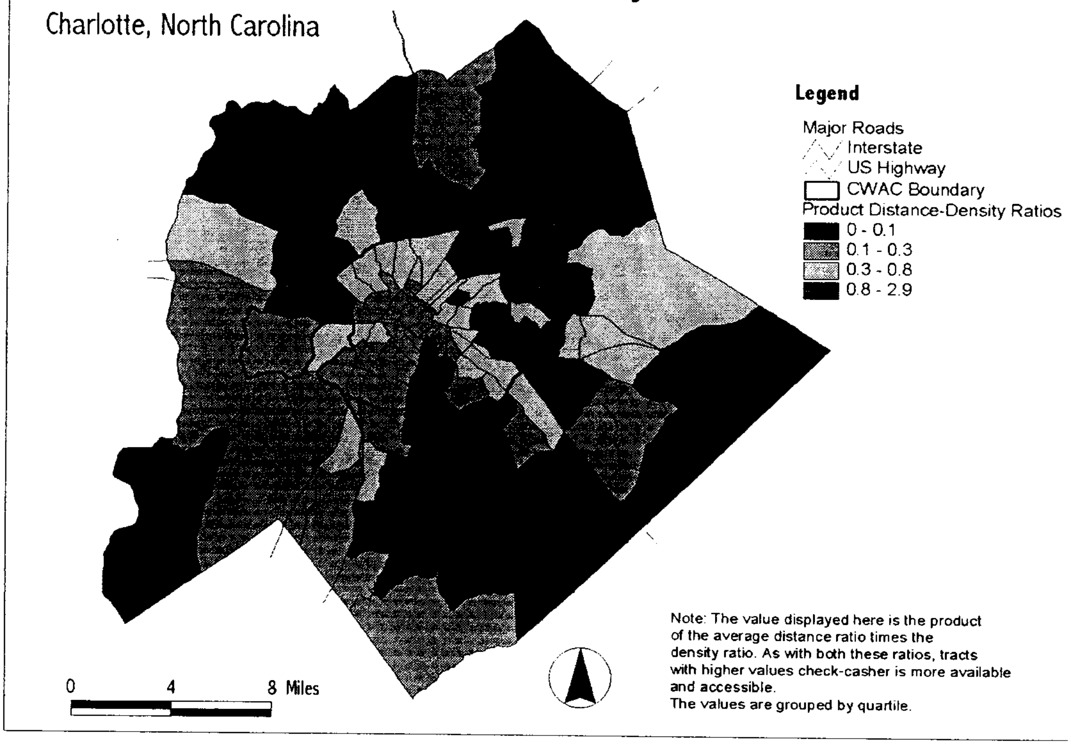
Ratio: Average Distance to Nearest Bank to Average Distance to Nearest Check-Casher



Ratio: Number of Check-Cashers to Number of Banks in a 4,250 m Radius



Product: Nearest Distance Ratio x Density Ratio



Residual: Spatial Lag Model of Square Root of the Product of the Nearest Distance Ratio x Density Ratio